

# NCS2550

## 750 MHz Voltage Feedback Op Amp

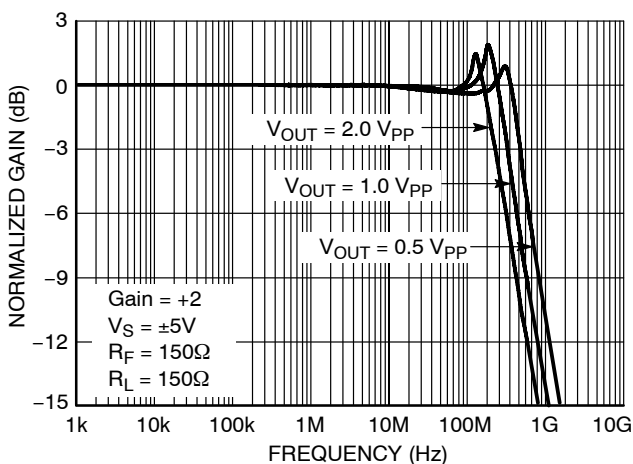
NCS2550 is a 750 MHz voltage feedback monolithic operational amplifier featuring high slew rate and low differential gain and phase error. The voltage feedback architecture allows for a superior bandwidth and low power consumption.

### Features

- -3.0 dB Small Signal BW ( $A_V = +2.0$ ,  $V_O = 0.5 V_{p-p}$ ) 750 MHz Typ
- Slew Rate 1700 V/ $\mu$ s
- Supply Current 13 mA
- Input Referred Voltage Noise 5.0 nV/ $\sqrt{\text{Hz}}$
- THD -64 dBc ( $f = 5.0$  MHz,  $V_O = 2.0 V_{p-p}$ )
- Output Current 100 mA
- Pin Compatible with EL5157, AD8057
- This is a Pb-Free Device

### Applications

- Line Drivers
- Radar/Communication Receivers



**Figure 1. Frequency Response:**  
Gain (dB) vs. Frequency  $A_V = +2.0$



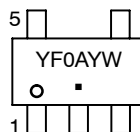
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### MARKING DIAGRAM

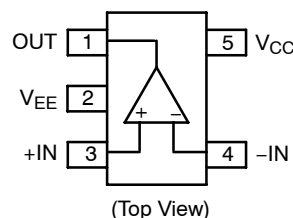


**SOT23-5  
(TSOP-5)  
SN SUFFIX  
CASE 483**



YF0, N2550 = NCS2550  
A = Assembly Location  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

### SOT23-5 (TSOP-5) PINOUT



### ORDERING INFORMATION

Device	Package	Shipping†
NCS2550SNT1G	SOT23-5 (TSOP-5) (Pb-Free)	3000/Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

PIN FUNCTION DESCRIPTION

Pin (SOT23/SC70)	Symbol	Function	Equivalent Circuit
1	OUT	Output	
2	$V_{EE}$	Negative Power Supply	
3	+IN	Non-inverted Input	
4	-IN	Inverted Input	See Above
5	$V_{CC}$	Positive Power Supply	

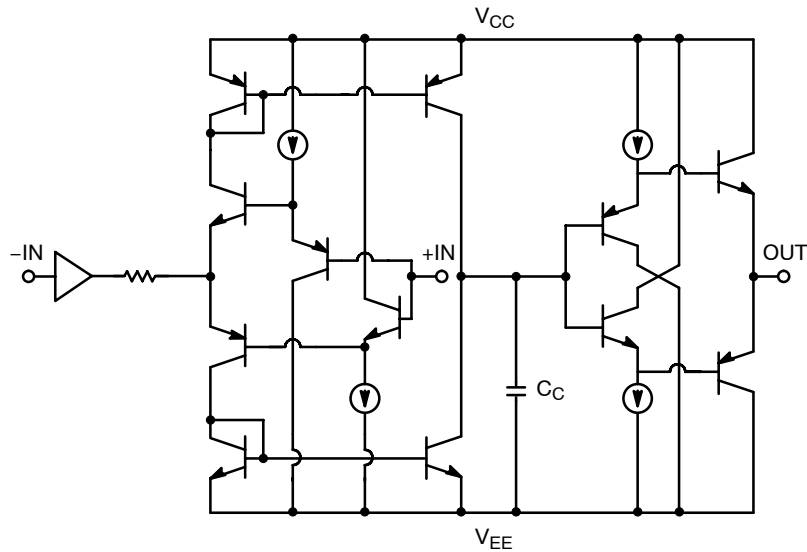


Figure 2. Simplified Device Schematic

## ATTRIBUTES

Characteristics	Value
ESD	
Human Body Model	2.0 kV
Machine Model	200 V
Charged Device Model	1.0 kV
Moisture Sensitivity (Note 1)	Level 1
Flammability Rating      Oxygen Index: 28 to 34	UL 94 V-0 @ 0.125 in

1. For additional information, see Application Note AND8003/D.

## MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Power Supply Voltage	$V_S$	11	Vdc
Input Voltage Range	$V_I$	$\leq V_S$	Vdc
Input Differential Voltage Range	$V_{ID}$	$\leq V_S$	Vdc
Output Current	$I_O$	100	mA
Maximum Junction Temperature (Note 2)	$T_J$	150	°C
Operating Ambient Temperature	$T_A$	-40 to +85	°C
Storage Temperature Range	$T_{stg}$	-60 to +150	°C
Power Dissipation	$P_D$	(See Graph)	mW
Thermal Resistance, Junction-to-Air	$R_{\theta JA}$	158	°C/W

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

2. Power dissipation must be considered to ensure maximum junction temperature ( $T_J$ ) is not exceeded.

## MAXIMUM POWER DISSIPATION

The maximum power that can be safely dissipated is limited by the associated rise in junction temperature. For the plastic packages, the maximum safe junction temperature is 150°C. If the maximum is exceeded momentarily, proper circuit operation will be restored as soon as the die temperature is reduced. Leaving the device in the “overheated” condition for an extended period can result in device damage.

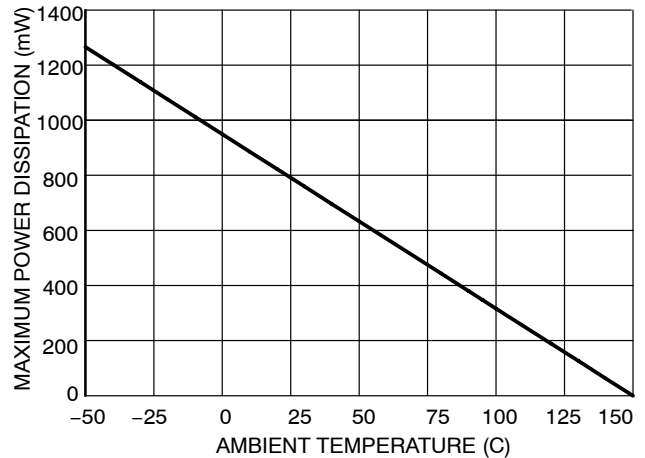


Figure 3. Power Dissipation vs. Temperature

# NCS2550

**AC ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +5.0\text{ V}$ ,  $V_{EE} = -5.0\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $R_L = 150\ \Omega$  to GND,  $R_F = 150\ \Omega$ ,  $A_V = +2.0$ , Enable is left open, unless otherwise specified).

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
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## FREQUENCY DOMAIN PERFORMANCE

BW	Bandwidth 3.0 dB Small Signal 3.0 dB Large Signal	$A_V = +2.0$ , $V_O = 0.5\text{ V}_{p-p}$ $A_V = +2.0$ , $V_O = 2.0\text{ V}_{p-p}$		750 350		MHz
GF <sub>0.1dB</sub>	0.1 dB Gain Flatness Bandwidth	$A_V = +2.0$		40		MHz
dG	Differential Gain	$A_V = +2.0$ , $R_L = 150\ \Omega$ , $f = 3.58\text{ MHz}$		0.07		%
dP	Differential Phase	$A_V = +2.0$ , $R_L = 150\ \Omega$ , $f = 3.58\text{ MHz}$		0.01		°

## TIME DOMAIN RESPONSE

SR	Slew Rate	$A_V = +2.0$ , $V_{step} = 2.0\text{ V}$		1700		V/ $\mu\text{s}$
$t_s$	Settling Time 0.1%	$A_V = +2.0$ , $V_{step} = 2.0\text{ V}$		10		ns
$t_r$ , $t_f$	Rise and Fall Time	(10%–90%) $A_V = +2.0$ , $V_{step} = 2.0\text{ V}$		2.0		ns

## HARMONIC/NOISE PERFORMANCE

THD	Total Harmonic Distortion	$f = 5.0\text{ MHz}$ , $V_O = 2.0\text{ V}_{p-p}$		–64		dB
HD2	2nd Harmonic Distortion	$f = 5.0\text{ MHz}$ , $V_O = 2.0\text{ V}_{p-p}$		–65		dBc
HD3	3rd Harmonic Distortion	$f = 5.0\text{ MHz}$ , $V_O = 2.0\text{ V}_{p-p}$		–75		dBc
IP3	Third-Order Intercept	$f = 10\text{ MHz}$ , $V_O = 1.0\text{ V}_{p-p}$		40		dBm
SFDR	Spurious-Free Dynamic Range	$f = 5.0\text{ MHz}$ , $V_O = 2.0\text{ V}_{p-p}$		65		dBc
$e_N$	Input Referred Voltage Noise	$f = 1.0\text{ MHz}$		5.0		nV/ $\sqrt{\text{Hz}}$
$i_N$	Input Referred Current Noise	$f = 1.0\text{ MHz}$		4.0		pA/ $\sqrt{\text{Hz}}$

# NCS2550

**DC ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +5.0\text{ V}$ ,  $V_{EE} = -5.0\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $R_L = 150\ \Omega$  to GND,  $R_F = 150\ \Omega$ ,  $A_V = +2.0$ , Enable is left open, unless otherwise specified).

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
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## DC PERFORMANCE

$V_{IO}$	Input Offset Voltage		-10	0	+10	mV
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Temperature Coefficient			6.0		$\mu\text{V}/^\circ\text{C}$
$I_{IB}$	Input Bias Current	$V_O = 0\text{ V}$		$\pm 3.2$	$\pm 20$	$\mu\text{A}$
$\Delta I_{IB}/\Delta T$	Input Bias Current Temperature Coefficient	$V_O = 0\text{ V}$		$\pm 40$		$\text{nA}/^\circ\text{C}$

## INPUT CHARACTERISTICS

$V_{CM}$	Input Common Mode Voltage Range (Note 3)		$\pm 3.0$	$\pm 3.2$		V
CMRR	Common Mode Rejection Ratio	(See Graph)	40	50		dB
$R_{IN}$	Input Resistance			4.5		$\text{M}\Omega$
$C_{IN}$	Differential Input Capacitance			1.0		pF

## OUTPUT CHARACTERISTICS

$R_{OUT}$	Output Resistance	Closed Loop Open Loop		0.1 11		$\Omega$
$V_O$	Output Voltage Range		$\pm 3.0$	$\pm 4.0$		V
$I_O$	Output Current		$\pm 50$	$\pm 100$		mA

## POWER SUPPLY

$V_S$	Operating Voltage Supply			10		V
$I_S$	Power Supply Current		5.0	13	17	mA
PSRR	Power Supply Rejection Ratio	(See Graph)	40	56		dB

3. Guaranteed by design and/or characterization.

# NCS2550

**AC ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +2.5\text{ V}$ ,  $V_{EE} = -2.5\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $R_L = 150\ \Omega$  to GND,  $R_F = 150\ \Omega$ ,  $A_V = +2.0$ , Enable is left open, unless otherwise specified).

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
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## FREQUENCY DOMAIN PERFORMANCE

BW	Bandwidth 3.0 dB Small Signal 3.0 dB Large Signal	$A_V = +2.0$ , $V_O = 0.5\text{ V}_{p-p}$ $A_V = +2.0$ , $V_O = 1.0\text{ V}_{p-p}$		550 200		MHz
GF <sub>0.1dB</sub>	0.1 dB Gain Flatness Bandwidth	$A_V = +2.0$		35		MHz
dG	Differential Gain	$A_V = +2.0$ , $R_L = 150\ \Omega$ , $f = 3.58\text{ MHz}$		0.07		%
dP	Differential Phase	$A_V = +2.0$ , $R_L = 150\ \Omega$ , $f = 3.58\text{ MHz}$		0.02		°

## TIME DOMAIN RESPONSE

SR	Slew Rate	$A_V = +2.0$ , $V_{step} = 1.0\text{ V}$		900		V/ $\mu\text{s}$
$t_s$	Settling Time 0.1%	$A_V = +2.0$ , $V_{step} = 1.0\text{ V}$		10		ns
$t_r$ , $t_f$	Rise and Fall Time	(10%–90%) $A_V = +2.0$ , $V_{step} = 1.0\text{ V}$		1.7		ns

## HARMONIC/NOISE PERFORMANCE

THD	Total Harmonic Distortion	$f = 5.0\text{ MHz}$ , $V_O = 1.0\text{ V}_{p-p}$		–60		dB
HD2	2nd Harmonic Distortion	$f = 5.0\text{ MHz}$ , $V_O = 1.0\text{ V}_{p-p}$		–65		dBc
HD3	3rd Harmonic Distortion	$f = 5.0\text{ MHz}$ , $V_O = 1.0\text{ V}_{p-p}$		–63		dBc
IP3	Third-Order Intercept	$f = 10\text{ MHz}$ , $V_O = 0.5\text{ V}_{p-p}$		35		dBm
SFDR	Spurious-Free Dynamic Range	$f = 5.0\text{ MHz}$ , $V_O = 1.0\text{ V}_{p-p}$		63		dBc
$e_N$	Input Referred Voltage Noise	$f = 1.0\text{ MHz}$		5.0		nV/ $\sqrt{\text{Hz}}$
$i_N$	Input Referred Current Noise	$f = 1.0\text{ MHz}$		4.0		pA/ $\sqrt{\text{Hz}}$

# NCS2550

**DC ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +2.5\text{ V}$ ,  $V_{EE} = -2.5\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $R_L = 150\ \Omega$  to GND,  $R_F = 150\ \Omega$ ,  $A_V = +2.0$ , Enable is left open, unless otherwise specified).

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
--------	----------------	------------	-----	-----	-----	------

## DC PERFORMANCE

$V_{IO}$	Input Offset Voltage		-10	0	+10	mV
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Temperature Coefficient			6.0		$\mu\text{V}/^\circ\text{C}$
$I_{IB}$	Input Bias Current	$V_O = 0\text{ V}$		$\pm 3.2$	$\pm 20$	$\mu\text{A}$
$\Delta I_{IB}/\Delta T$	Input Bias Current Temperature Coefficient	$V_O = 0\text{ V}$		$\pm 40$		$\text{nA}/^\circ\text{C}$

## INPUT CHARACTERISTICS

$V_{CM}$	Input Common Mode Voltage Range (Note 3)		$\pm 1.1$	$\pm 1.5$		V
CMRR	Common Mode Rejection Ratio	(See Graph)	40	50		dB
$R_{IN}$	Input Resistance			4.5		$\text{M}\Omega$
$C_{IN}$	Differential Input Capacitance			1.0		pF

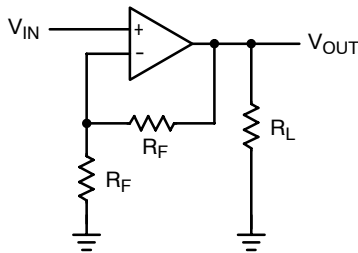
## OUTPUT CHARACTERISTICS

$R_{OUT}$	Output Resistance	Closed Loop Open Loop		0.1 11		$\Omega$
$V_O$	Output Voltage Range		$\pm 1.1$	$\pm 1.5$		V
$I_O$	Output Current		$\pm 50$	$\pm 100$		mA

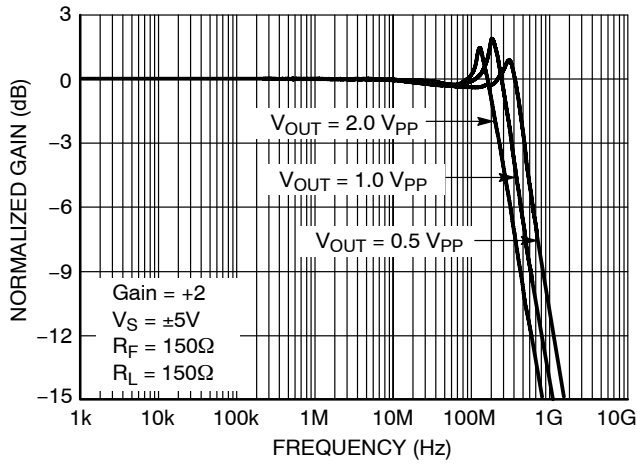
## POWER SUPPLY

$V_S$	Operating Voltage Supply			5.0		V
$I_S$	Power Supply Current		5.0	11	17	mA
PSRR	Power Supply Rejection Ratio	(See Graph)	40	56		dB

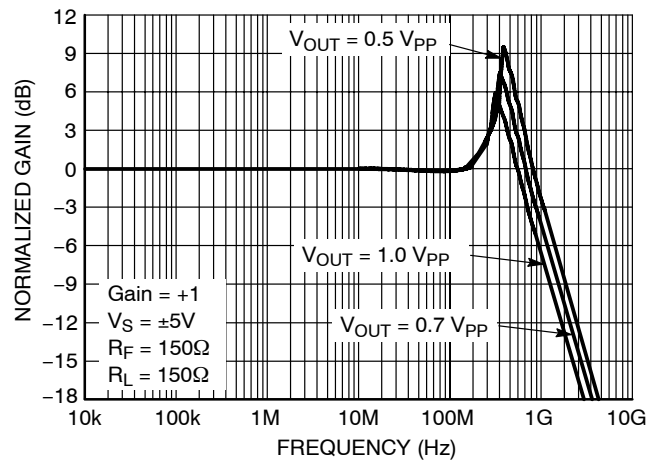
4. Guaranteed by design and/or characterization.



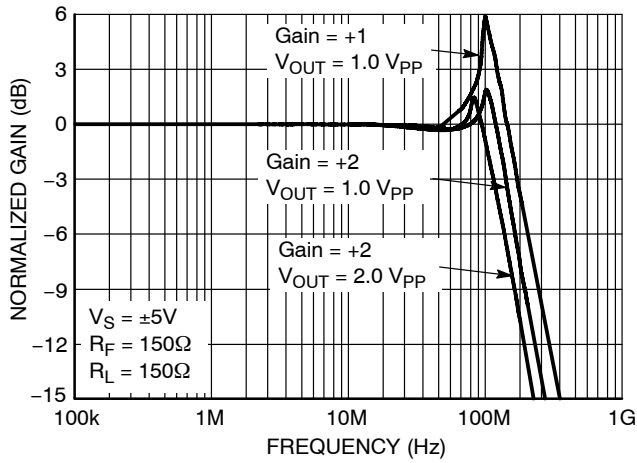
**Figure 4. Typical Test Setup**  
( $A_V = +2.0$ ,  $R_F = 150\ \Omega$ ,  $R_L = 150\ \Omega$ )



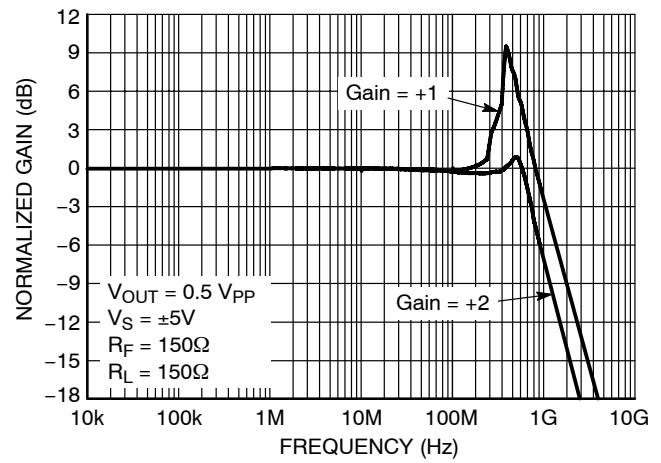
**Figure 5. Frequency Response:**  
Gain (dB) vs. Frequency  
 $A_v = +2.0$



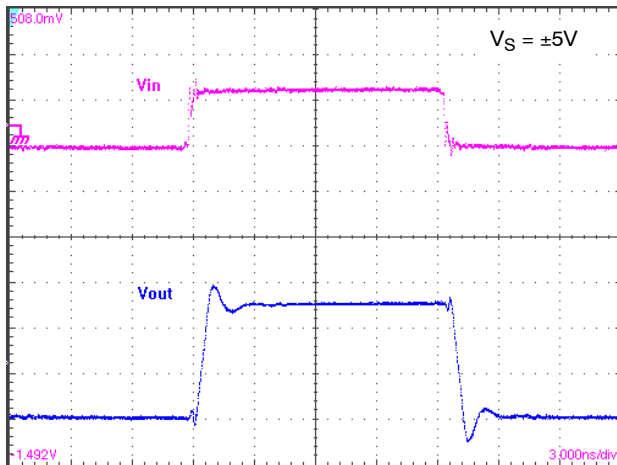
**Figure 6. Frequency Response:**  
Gain (dB) vs. Frequency  
 $A_v = +1.0$



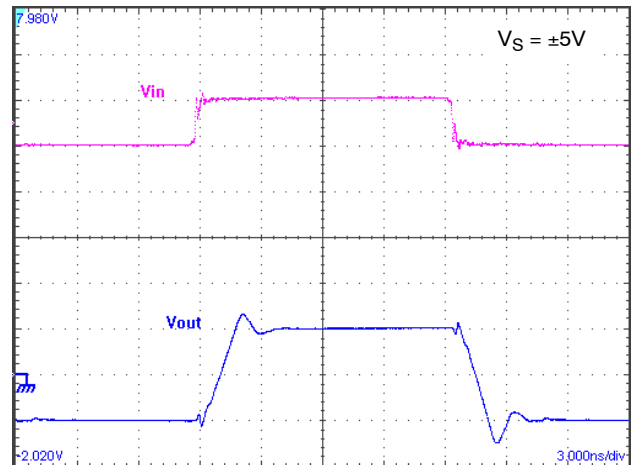
**Figure 7. Large Signal Frequency Response**  
Gain (dB) vs. Frequency



**Figure 8. Small Signal Frequency Response**  
Gain (dB) vs. Frequency



**Figure 9. Small Signal Step Response**  
Vertical: 20 mV/div  
Horizontal: 3 ns/div



**Figure 10. Large Signal Step Response**  
Vertical: 1 V/div  
Horizontal: 3 ns/div



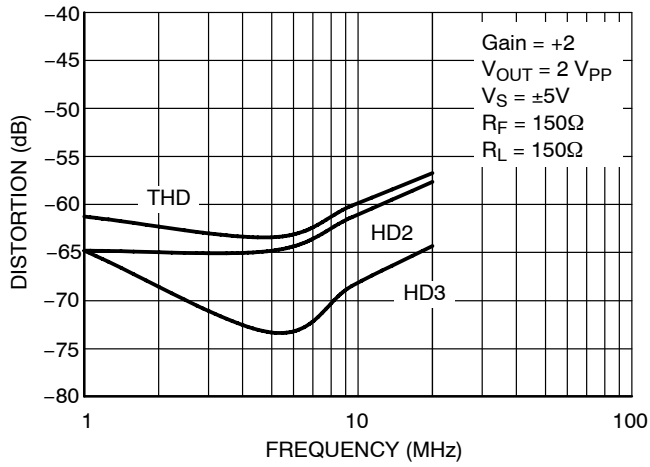


Figure 11. THD, HD2, HD3 vs. Frequency

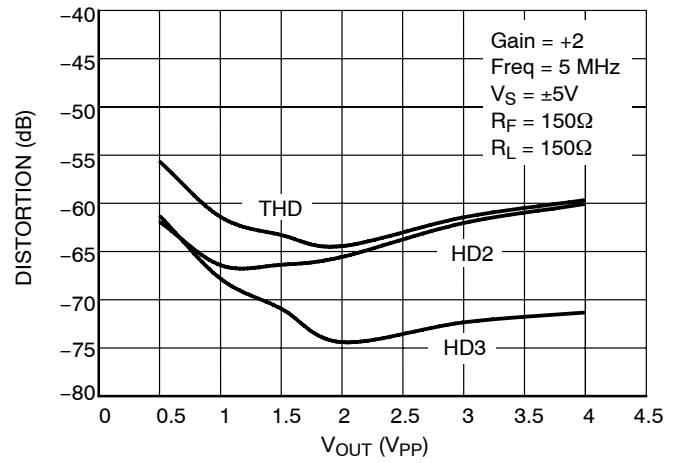


Figure 12. THD, HD2, HD3 vs. Output Voltage

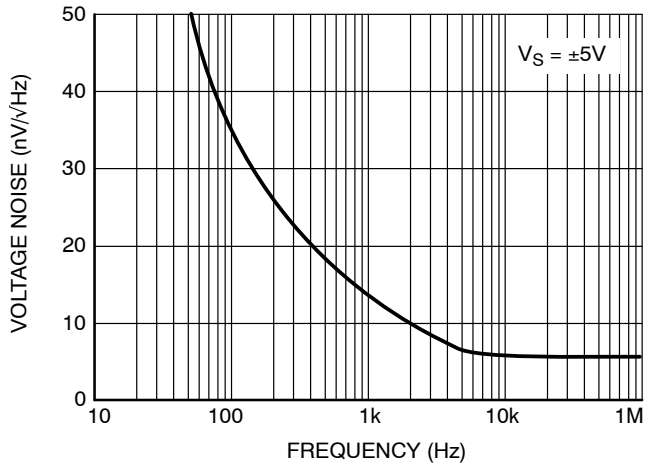


Figure 13. Input Referred Voltage Noise vs. Frequency

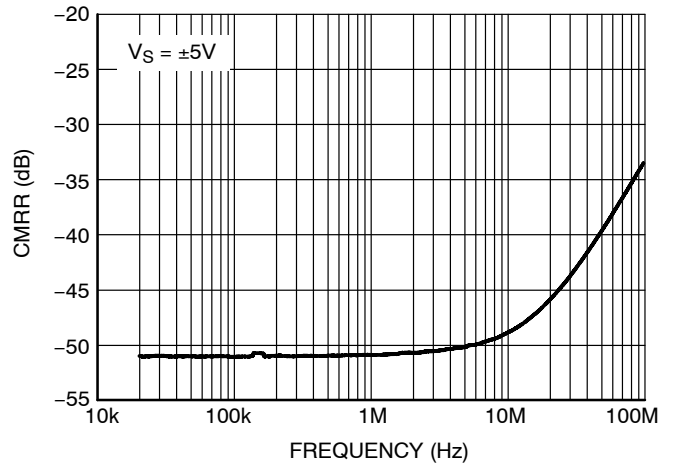


Figure 14. CMRR vs. Frequency

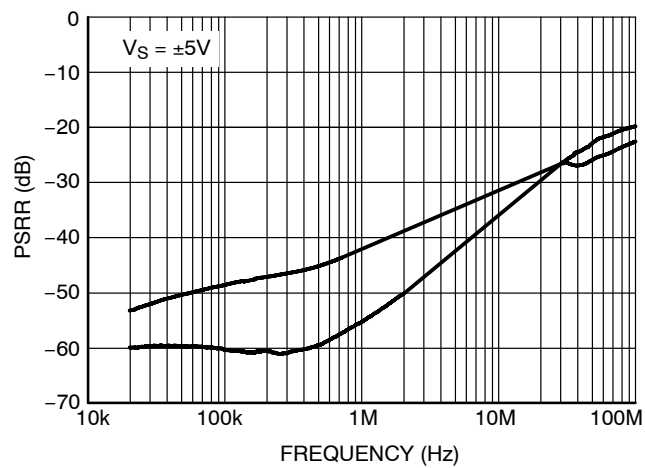


Figure 15. PSRR vs. Frequency

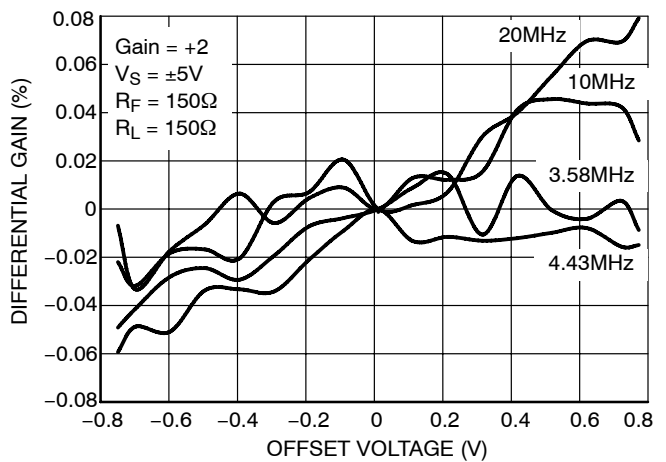


Figure 16. Differential Gain

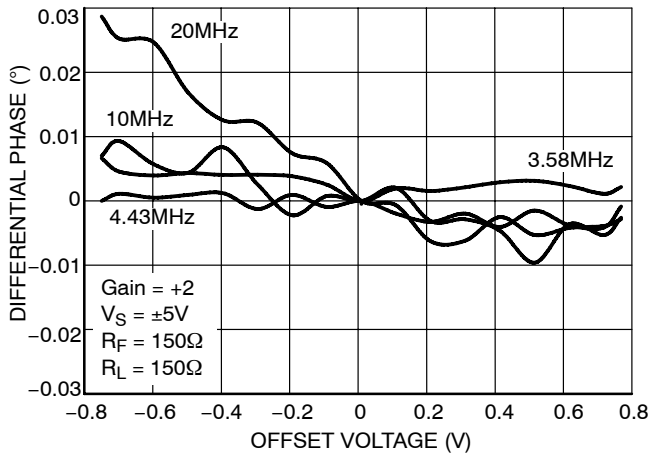


Figure 17. Differential Phase

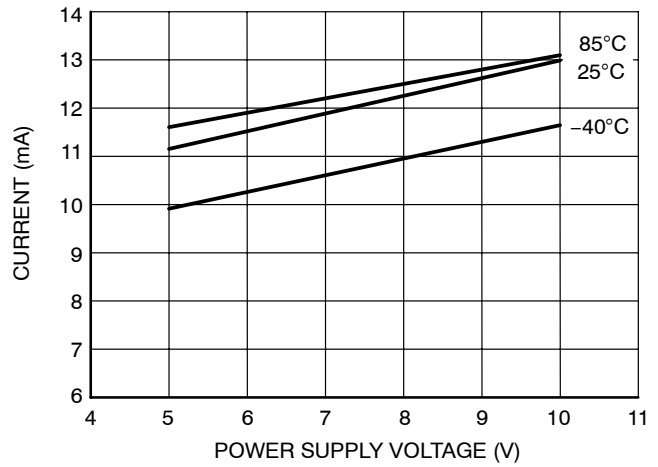


Figure 18. Supply Current vs. Power Supply

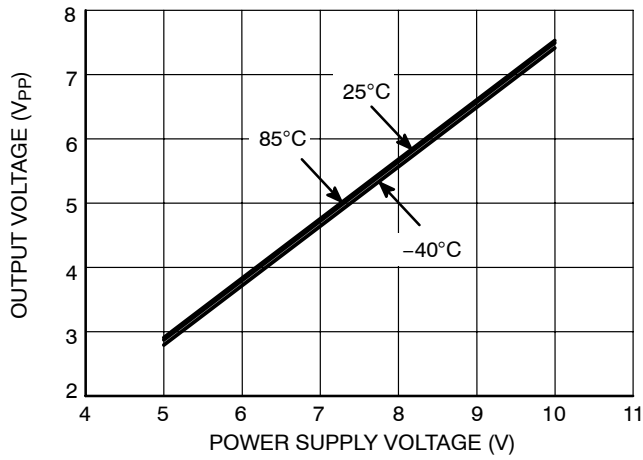


Figure 19. Output Voltage Swing vs. Supply Voltage

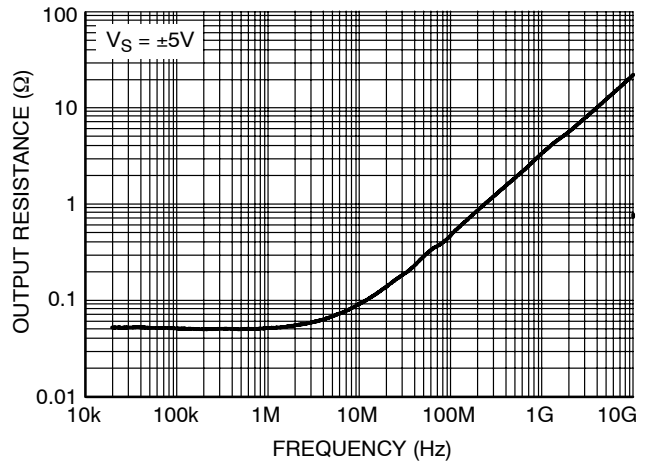


Figure 20. Closed Loop Output Resistance vs. Frequency

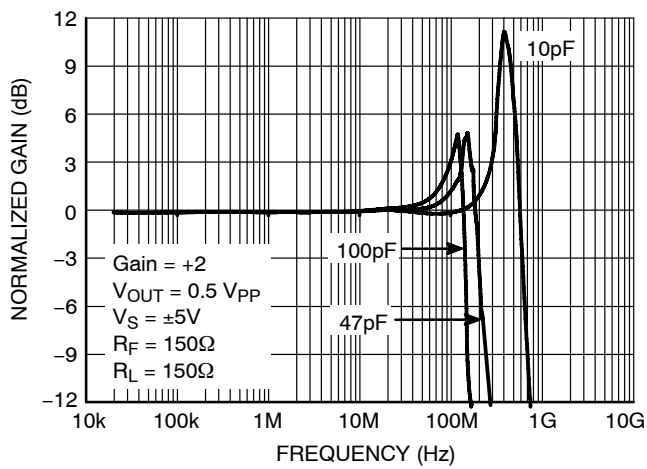


Figure 21. Frequency Response vs. Capacitive Load

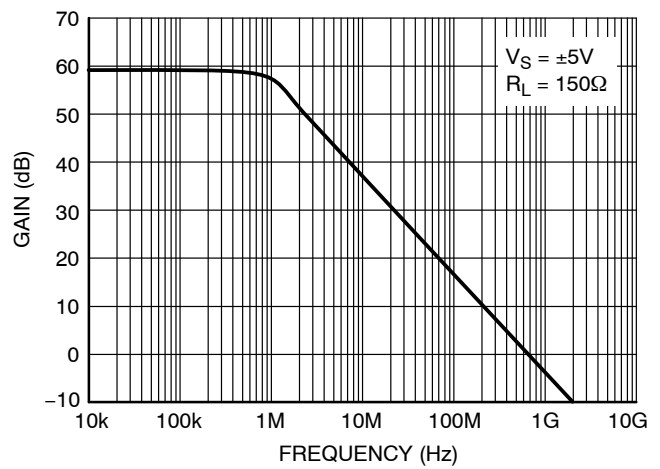


Figure 22. Voltage Gain vs. Frequency

### Printed Circuit Board Layout Techniques

Proper high speed PCB design rules should be used for all wideband amplifiers as the PCB parasitics can affect the overall performance. Most important are stray capacitances at the output and inverting input nodes as it can effect peaking and bandwidth. A space (3/16" is plenty) should be left around the signal lines to minimize coupling. Also, signal lines connecting the feedback and gain resistors should be short enough so that their associated inductance does not cause high frequency gain errors. Line lengths less than 1/4" are recommended.

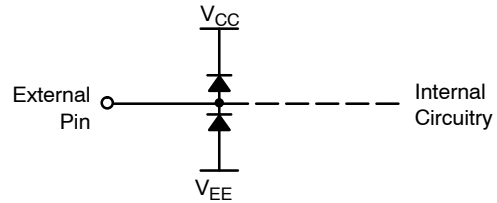
### Video Performance

This device designed to provide good performance with NTSC, PAL, and HDTV video signals. Best performance is obtained with back terminated loads as performance is degraded as the load is increased. The back termination reduces reflections from the transmission line and effectively masks transmission line and other parasitic capacitances from the amplifier output stage.

### ESD Protection

All device pins have limited ESD protection using internal diodes to power supplies as specified in the attributes table

(see Figure 23). These diodes provide moderate protection to input overdrive voltages above the supplies. The ESD diodes can support high input currents with current limiting series resistors. Keep these resistor values as low as possible since high values degrade both noise performance and frequency response. Under closed-loop operation, the ESD diodes have no effect on circuit performance. However, under certain conditions the ESD diodes will be evident. If the device is driven into a slewing condition, the ESD diodes will clamp large differential voltages until the feedback loop restores closed-loop operation. Also, if the device is powered down and a large input signal is applied, the ESD diodes will conduct.

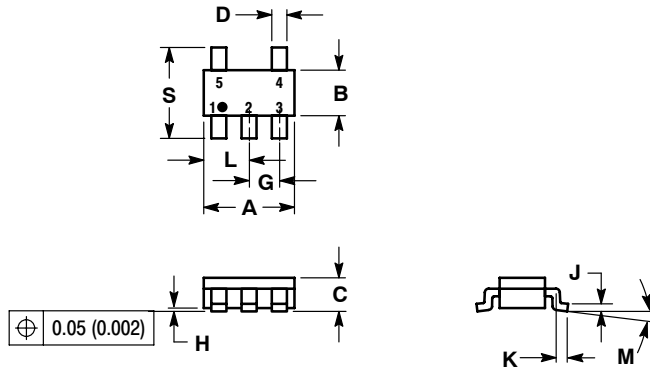


**Figure 23. Internal ESD Protection**

# NCS2550

## PACKAGE DIMENSIONS

TSOP-5  
SN SUFFIX  
CASE 483-02  
ISSUE E

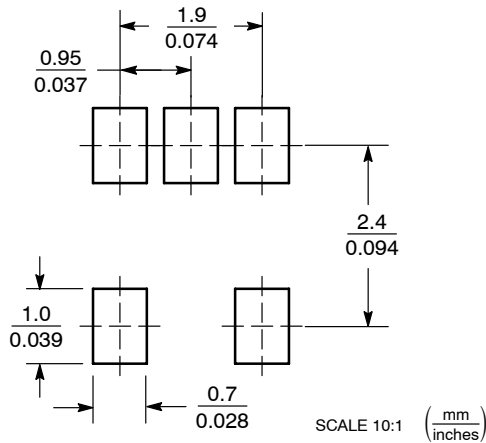


### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. A AND B DIMENSIONS DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.90	3.10	0.1142	0.1220
B	1.30	1.70	0.0512	0.0669
C	0.90	1.10	0.0354	0.0433
D	0.25	0.50	0.0098	0.0197
G	0.85	1.05	0.0335	0.0413
H	0.013	0.100	0.0005	0.0040
J	0.10	0.26	0.0040	0.0102
K	0.20	0.60	0.0079	0.0236
L	1.25	1.55	0.0493	0.0610
M	0°	10°	0°	10°
S	2.50	3.00	0.0985	0.1181

## SOLDERING FOOTPRINT\*



\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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