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NCS2500

1.1 mA 200 MHz Current Feedback Op Amp

NCS2500 is a 1.1 mA 200 MHz current feedback monolithic operational amplifier featuring high slew rate and low differential gain and phase error. The current 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}) 200 MHz Typ
- Slew Rate 450 V/μs
- Supply Current 1.1 mA
- Input Referred Voltage Noise 4.0 nV/$\sqrt{Hz}$
- THD −55 dB (f = 5.0 MHz, V_O = 2.0 V_{p-p})
- Output Current 100 mA
- Pin Compatible with EL5161, LMH6723, MAX4452
- Pb−Free Packages are Available

Applications

- Portable Video
- Line Drivers
- Radar/Communication Receivers
- Set Top Box
- NTSC/PAL/HDTV

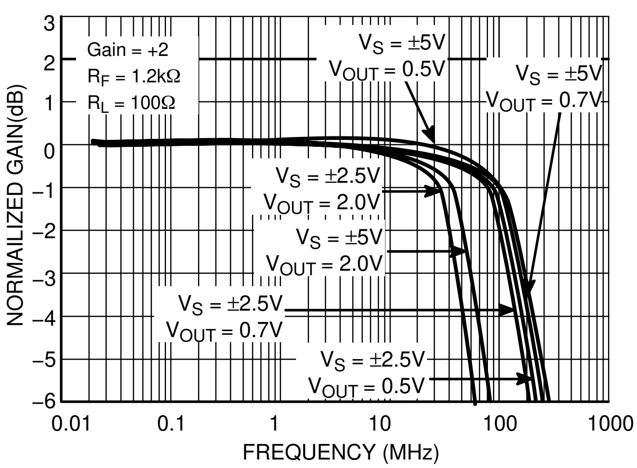

Figure 1. Frequency Response: Gain (dB) vs. Frequency Av = +2.0, R_L = 100 Ω

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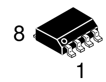
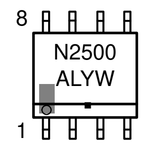
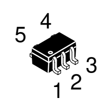
MARKING DIAGRAMS

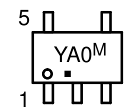


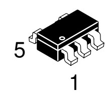
SO−8
D SUFFIX
CASE 751



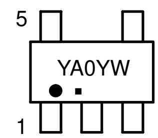


SC−70−5
(SC−88A)
SQ SUFFIX
CASE 419A



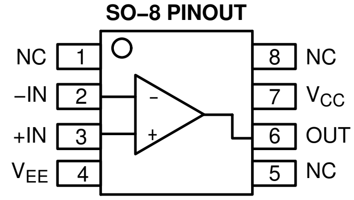


SOT23−5
(TSOP−5)
SN SUFFIX
CASE 483



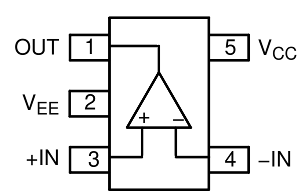
YA0, N2500	= NCS2500
A	= Assembly Location
L	= Wafer Lot
Y	= Year
W	= Work Week
M	= Date Code
▪	= Pb−Free Package

SO−8 PINOUT



(Top View)

SOT23−5/SC70−5 PINOUT



(Top View)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 13 of this data sheet.

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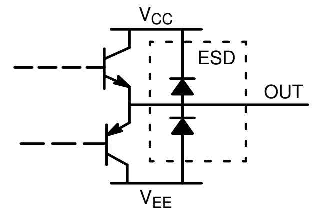
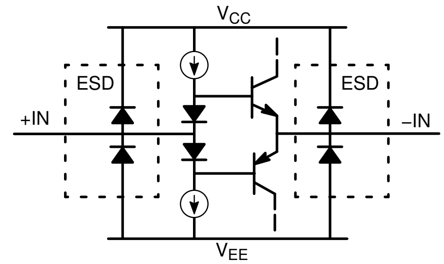
PIN FUNCTION DESCRIPTION

Pin (SO−8)	Pin (SOT23/SC70)	Symbol	Function	Equivalent Circuit
6	1	OUT	Output	
4	2	V_{EE}	Negative Power Supply	
3	3	+IN	Non−inverted Input	
2	4	−IN	Inverted Input	See Above
7	5	V_{CC}	Positive Power Supply	
1, 5, 8	N/A	NC	No Connect	

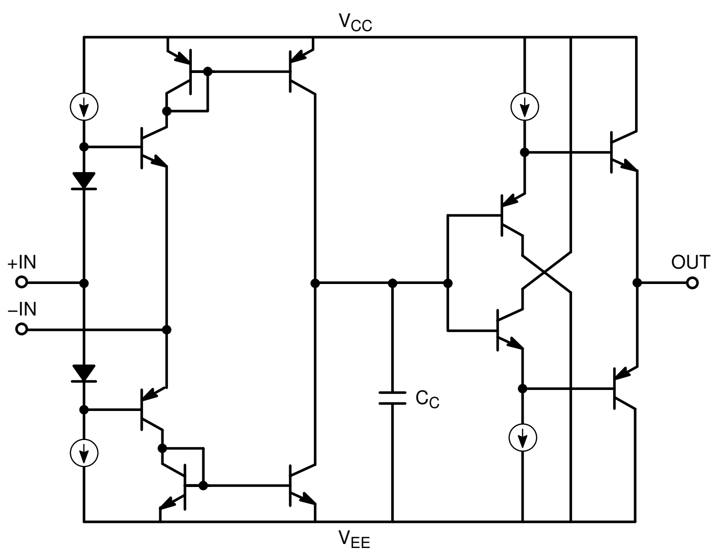


Figure 2. Simplified Device Schematic

ATTRIBUTES

Characteristics		Value
ESD Human Body Model Machine Model Charged Device Model		 2.0 kV (Note 1) 200 V 1.0 kV
Moisture Sensitivity (Note 2)		Level 1
Flammability Rating	Oxygen Index: 28 to 34	UL 94 V−0 @ 0.125 in

1. 0.8 kV between the input pairs +IN and −IN pins only. All other pins are 2.0 kV.
2. For additional information, see Application Note AND8003/D.

MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Power Supply Voltage	V_S	11	V_{DC}
Input Voltage Range	V_I	$\leq V_S$	V_{DC}
Input Differential Voltage Range	V_{ID}	$\leq V_S$	V_{DC}
Output Current	I_O	100	mA
Maximum Junction Temperature (Note 3)	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 SO−8 SC70−5 SOT23−5	$R_{\theta JA}$	 172 215 154	°C/W

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

3. 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.

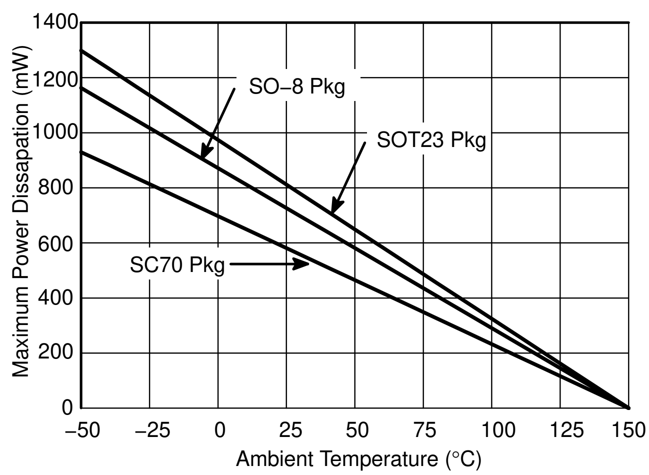


Figure 3. Power Dissipation vs. Temperature

AC ELECTRICAL CHARACTERISTICS (V_{CC} = +5.0 V, V_{EE} = –5.0 V, T_A = –40°C to +85°C, R_L = 100 Ω to GND, R_F = 1.2 kΩ, A_V = +2.0, V_{IN} = 0 V, unless otherwise specified).

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
FREQUENCY DOMAIN PERFORMANCE						
BW	Bandwidth 3.0 dB Small Signal 3.0 dB Large Signal	 A_V = +2.0, V_O = 0.5 V_{p-p} A_V = +2.0, V_O = 2.0 V_{p-p}		 200 140		MHz
$GF_{0.1dB}$	0.1 dB Gain Flatness Bandwidth	A_V = +2.0		30		MHz
dG	Differential Gain	A_V = +2.0, R_L = 150 Ω, f = 3.58 MHz		0.02		%
dP	Differential Phase	A_V = +2.0, R_L = 150 Ω, f = 3.58 MHz		0.1		°
TIME DOMAIN RESPONSE						
SR	Slew Rate	A_V = +2.0, V_{step} = 2.0 V		450		V/μs
t_s	Settling Time 0.01% 0.1%	 A_V = +2.0, V_{step} = 2.0 V A_V = +2.0, V_{step} = 2.0 V		 35 18		ns
t_r t_f	Rise and Fall Time	(10%–90%) A_V = +2.0, V_{step} = 2.0 V		5.0		ns
HARMONIC/NOISE PERFORMANCE						
THD	Total Harmonic Distortion	f = 5.0 MHz, V_O = 2.0 V_{p-p}, R_L = 150 Ω		–55		dB
HD2	2nd Harmonic Distortion	f = 5.0 MHz, V_O = 2.0 V_{p-p}		–67		dBc
HD3	3rd Harmonic Distortion	f = 5.0 MHz, V_O = 2.0 V_{p-p}		–57		dBc
IP3	Third−Order Intercept	f = 10 MHz, V_O = 2.0 V_{p-p}		35		dBm
SFDR	Spurious−Free Dynamic Range	f = 5.0 MHz, V_O = 2.0 V_{p-p}		58		dBc
e_N	Input Referred Voltage Noise	f = 1.0 MHz		4.0		$nV/\sqrt{Hz}$
i_N	Input Referred Current Noise	f = 1.0 MHz, Inverting f = 1.0 MHz, Non−Inverting		15 15		$pA/\sqrt{Hz}$

DC ELECTRICAL CHARACTERISTICS (V_{CC} = +5.0 V, V_{EE} = –5.0 V, T_A = –40°C to +85°C, R_L = 100 Ω to GND, R_F = 1.2 kΩ, A_V = +2.0, V_{IN} = 0 V, unless otherwise specified).

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
DC PERFORMANCE						
V_{OS}	Offset Voltage		–4.0	±0.7	+4.0	mV
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Temperature Coefficient			6.0		μV/°C
I_{IB}	Input Bias Current	+Input (Non−Inverting), V_O = 0 V −Input (Inverting), V_O = 0 V (Note 4)	–4.0 –4.0	±2.0 ±0.4	+4.0 +4.0	μA
$\Delta I_{IB}/\Delta T$	Input Bias Current Temperature Coefficient	+Input (Non−Inverting), V_O = 0 V −Input (Inverting), V_O = 0 V		±40 ±10		nA/°C
INPUT CHARACTERISTICS						
V_{CM}	Input Common Mode Voltage Range (Note 4)		±3.0	±4.0		V
CMRR	Common Mode Rejection Ratio	(See Graph)	50	55	65	dB
R_{IN}	Input Resistance	+Input (Non−Inverting) −Input (Inverting)		4.0 350		MΩ Ω
C_{IN}	Differential Input Capacitance			1.0		pF
OUTPUT CHARACTERISTICS						
R_{OUT}	Output Resistance			0.02		Ω
V_O	Output Voltage Swing		±3.0	±3.5		V
I_O	Output Current		±60	±100		mA
POWER SUPPLY						
V_S	Operating Voltage Supply			10		V
I_S	Power Supply Current	V_O = 0 V	0.5	1.1	2.0	mA
PSRR	Power Supply Rejection Ratio	(See Graph)	50	60	70	dB

4. Guaranteed by design and/or characterization.

AC ELECTRICAL CHARACTERISTICS (V_{CC} = +2.5 V, V_{EE} = –2.5 V, T_A = –40°C to +85°C, R_L = 100 Ω to GND, R_F = 1.2 kΩ, A_V = +2.0, V_{IN} = 0 V, unless otherwise specified).

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
FREQUENCY DOMAIN PERFORMANCE						
BW	Bandwidth 3.0 dB Small Signal 3.0 dB Large Signal	 A_V = +2.0, V_O = 0.5 V_{p-p} A_V = +2.0, V_O = 1.0 V_{p-p}		 180 130		MHz
$GF_{0.1dB}$	0.1 dB Gain Flatness Bandwidth	A_V = +2.0		15		MHz
dG	Differential Gain	A_V = +2.0, R_L = 150 Ω, f = 3.58 MHz		0.02		%
dP	Differential Phase	A_V = +2.0, R_L = 150 Ω, f = 3.58 MHz		0.1		°
TIME DOMAIN RESPONSE						
SR	Slew Rate	A_V = +2.0, V_{step} = 1.0 V		350		V/μs
t_s	Settling Time 0.01% 0.1%	 A_V = +2.0, V_{step} = 1.0 V A_V = +2.0, V_{step} = 1.0 V		 40 18		ns
t_r t_f	Rise and Fall Time	(10%–90%) A_V = +2.0, V_{step} = 1.0 V		8.0		ns
HARMONIC/NOISE PERFORMANCE						
THD	Total Harmonic Distortion	f = 5.0 MHz, V_O = 1.0 V_{p-p}, R_L = 150 Ω		–55		dB
HD2	2nd Harmonic Distortion	f = 5.0 MHz, V_O = 1.0 V_{p-p}		–67		dBc
HD3	3rd Harmonic Distortion	f = 5.0 MHz, V_O = 1.0 V_{p-p}		–57		dBc
IP3	Third–Order Intercept	f = 10 MHz, V_O = 1.0 V_{p-p}		35		dBm
SFDR	Spurious–Free Dynamic Range	f = 5.0 MHz, V_O = 1.0 V_{p-p}		58		dBc
e_N	Input Referred Voltage Noise	f = 1.0 MHz		4.0		$nV/\sqrt{Hz}$
i_N	Input Referred Current Noise	f = 1.0 MHz, Inverting f = 1.0 MHz, Non–Inverting		15 15		$pA/\sqrt{Hz}$

DC ELECTRICAL CHARACTERISTICS (V_{CC} = +2.5 V, V_{EE} = −2.5 V, T_A = −40°C to +85°C, R_L = 100 Ω to GND, R_F = 1.2 kΩ, A_V = +2.0, V_{IN} = 0 V, unless otherwise specified).

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
DC PERFORMANCE						
V_{OS}	Offset Voltage		−4.0	±0.5	+4.0	mV
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Temperature Coefficient			6.0		μV/°C
I_{IB}	Input Bias Current	+Input (Non−Inverting), V_O = 0 V −Input (Inverting), V_O = 0 V (Note 5)	−4.0 −4.0	±2.0 ±0.4	+4.0 +4.0	μA
$\Delta I_{IB}/\Delta T$	Input Bias Current Temperature Coefficient	+Input (Non−Inverting), V_O = 0 V −Input (Inverting), V_O = 0 V		±40 ±10		nA/°C
INPUT CHARACTERISTICS						
V_{CM}	Input Common Mode Voltage Range (Note 5)		±1.3	±1.5		V
CMRR	Common Mode Rejection Ratio	(See Graph)	50	55	65	dB
R_{IN}	Input Resistance	+Input (Non−Inverting) −Input (Inverting)		4.0 350		MΩ Ω
C_{IN}	Differential Input Capacitance			1.0		pF
OUTPUT CHARACTERISTICS						
R_{OUT}	Output Resistance			0.02		Ω
V_O	Output Voltage Swing		±1.1	±1.4		V
I_O	Output Current		±40	±80		mA
POWER SUPPLY						
V_S	Operating Voltage Supply			5.0		V
I_S	Power Supply Current	V_O = 0 V	0.5	0.9	1.9	mA
PSRR	Power Supply Rejection Ratio	(See Graph)	50	60	70	dB

5. Guaranteed by design and/or characterization.

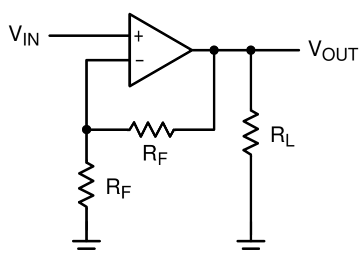


Figure 4. Typical Test Setup
(A_V = +2.0, R_F = 1.8 kΩ or 1.2 kΩ or 1.0 kΩ, R_L = 100 Ω)

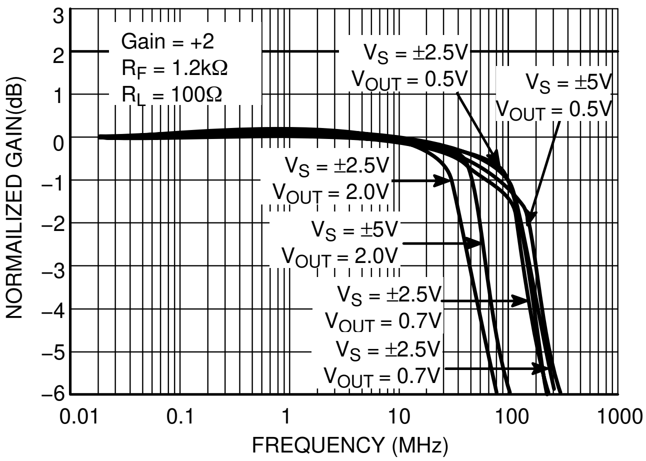


Figure 5. Frequency Response: Gain (dB) vs. Frequency Av = +2.0

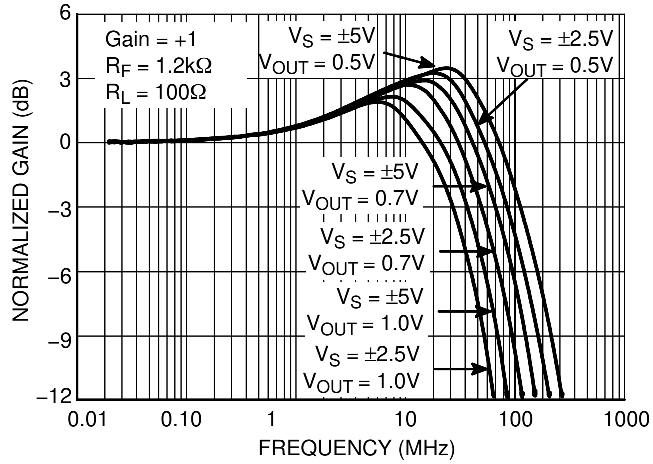


Figure 6. Frequency Response: Gain (dB) vs. Frequency Av = +1.0

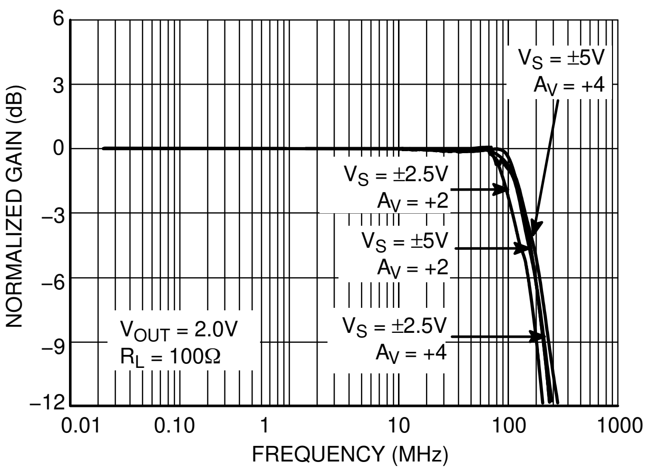


Figure 7. Large Signal Frequency Response Gain (dB) vs. Frequency

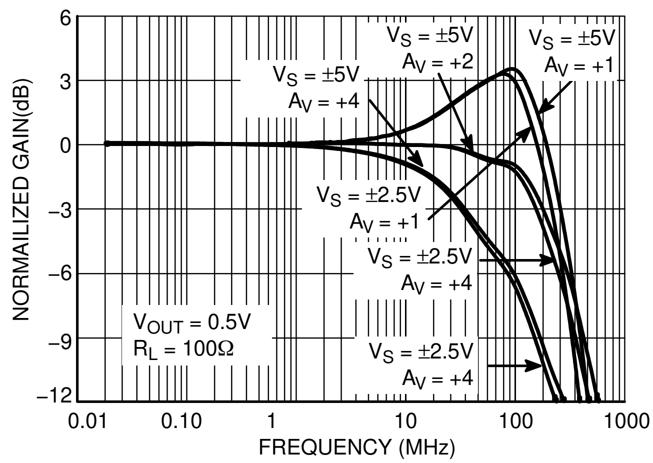


Figure 8. Small Signal Frequency Response Gain (dB) vs. Frequency

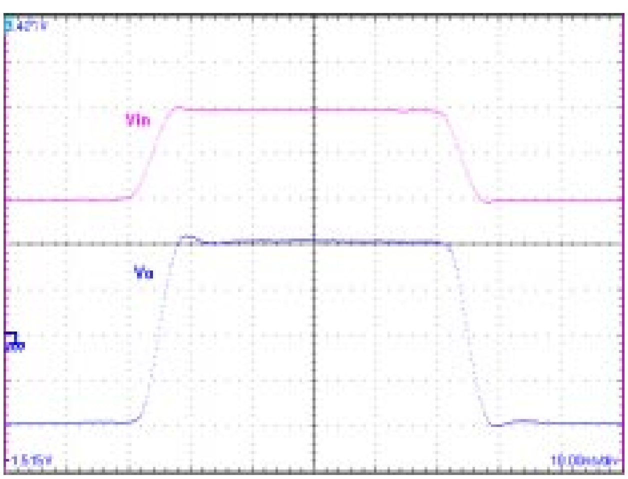


Figure 9. Small Signal Step Response Vertical: 500 mV/div Horizontal: 10 ns/div

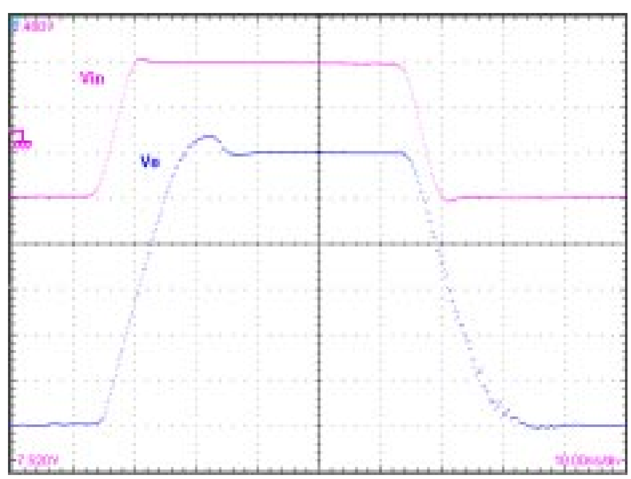


Figure 10. Large Signal Step Response Vertical: 500 mV/div Horizontal: 10 ns/div

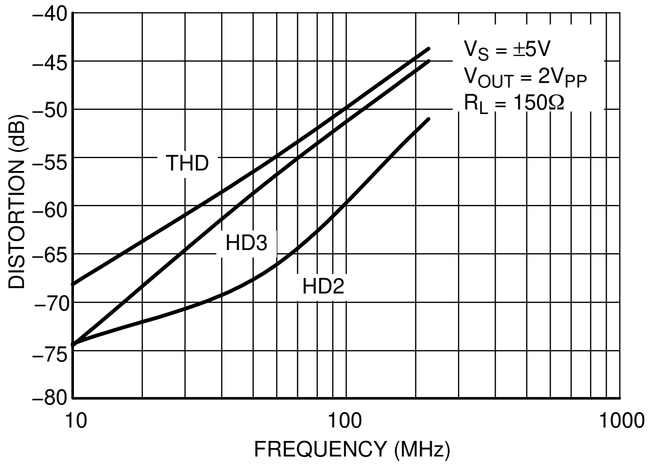


Figure 11. THD, HD2, HD3 vs. Frequency

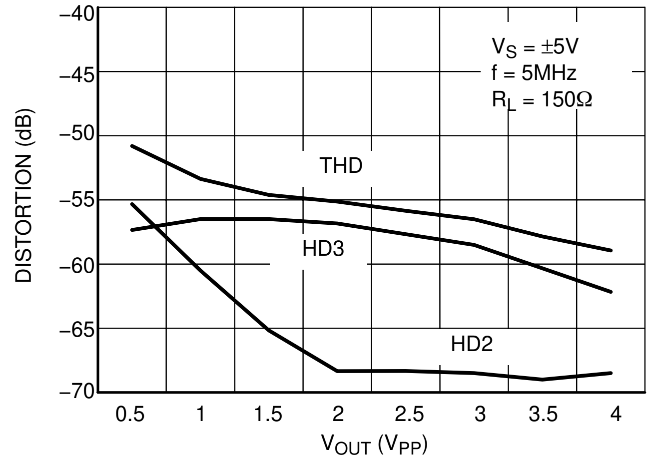


Figure 12. THD, HD2, HD3 vs. Output Voltage

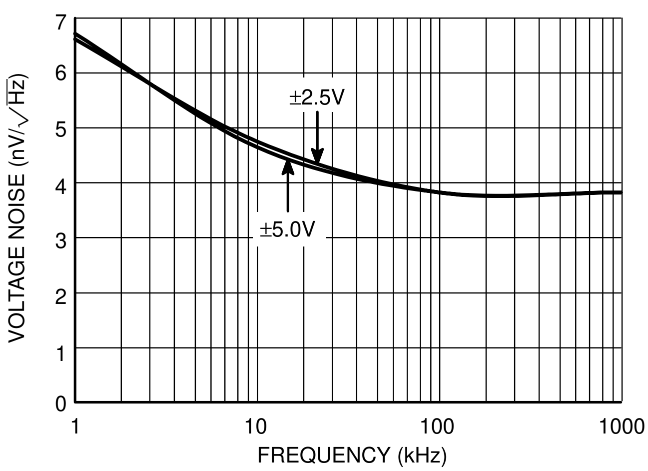


Figure 13. Input Referred Noise vs. Frequency

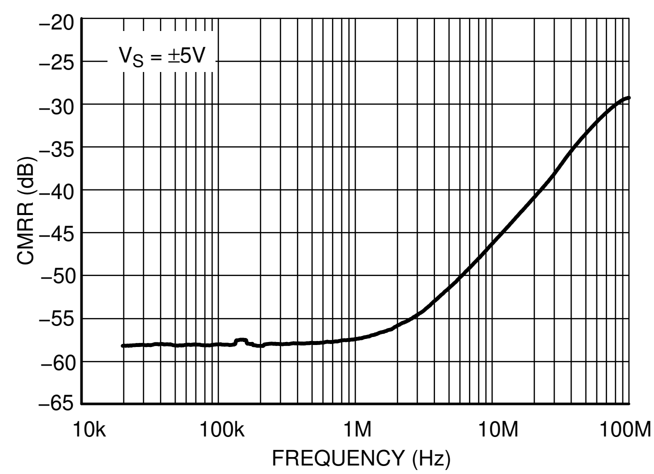


Figure 14. CMRR vs. Frequency

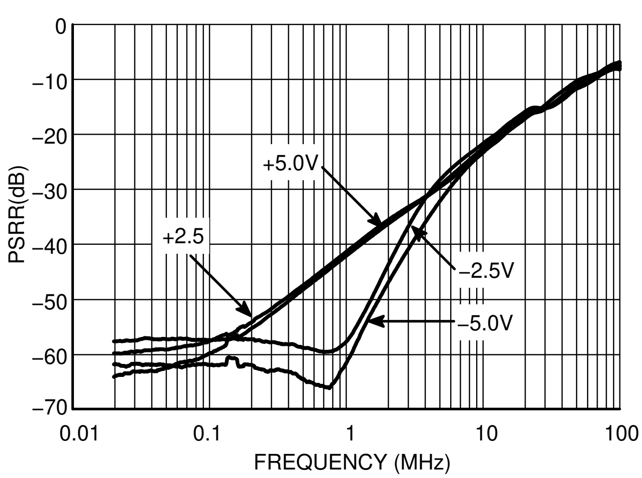


Figure 15. PSRR vs. Frequency

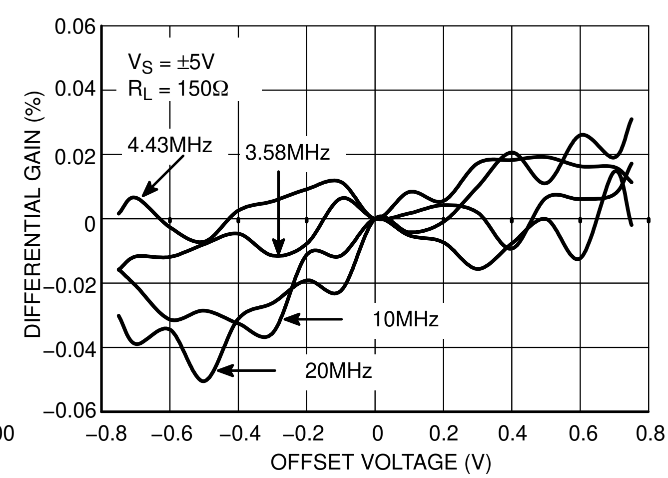


Figure 16. Differential Gain

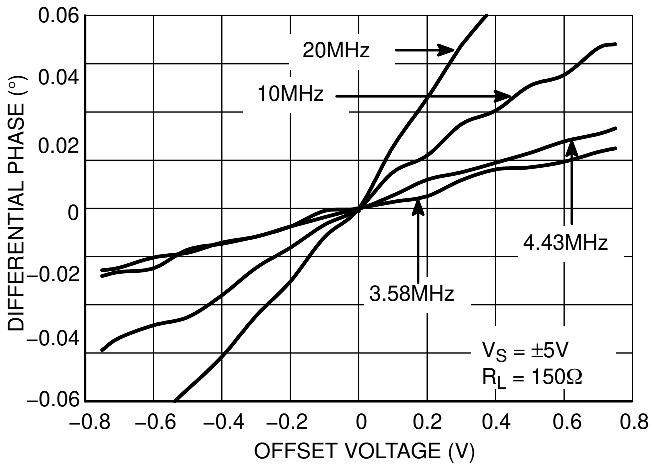


Figure 17. Differential Phase

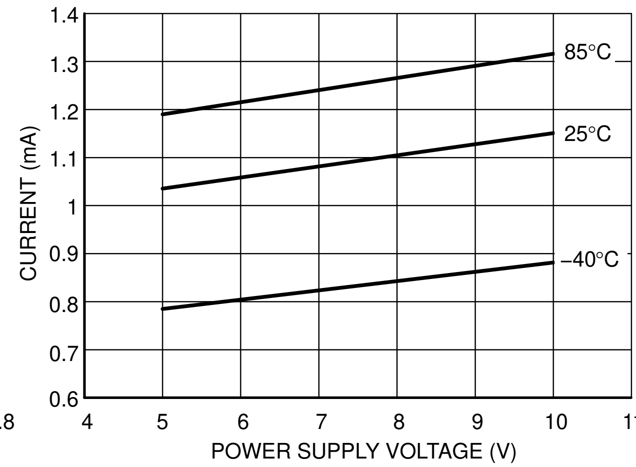


Figure 18. Supply Current vs. Power Supply

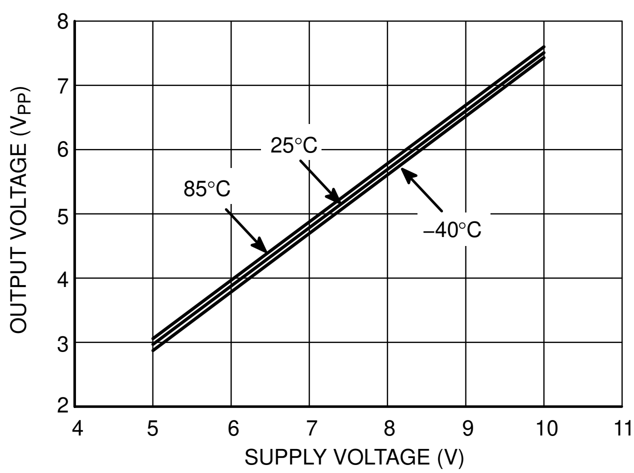


Figure 19. Output Voltage Swing vs. Supply Voltage

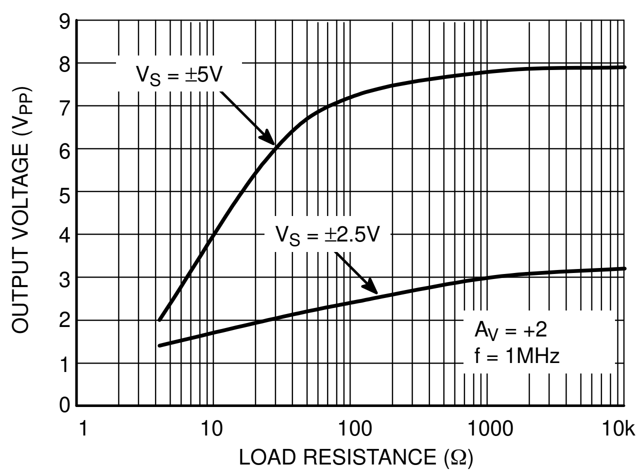


Figure 20. Output Voltage Swing vs. Load Resistance

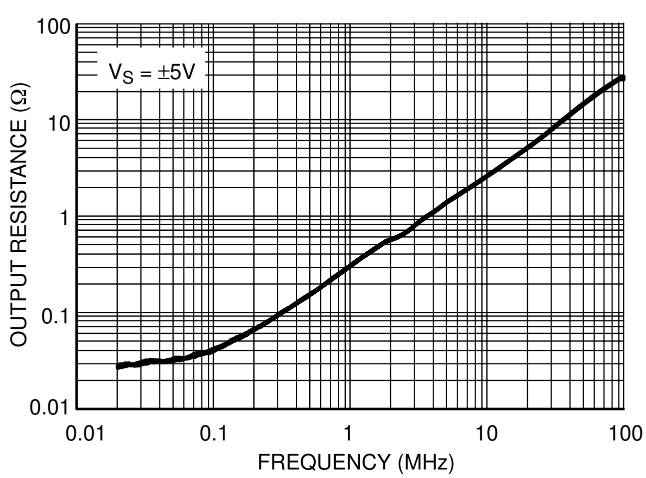


Figure 21. Output Impedance vs. Frequency

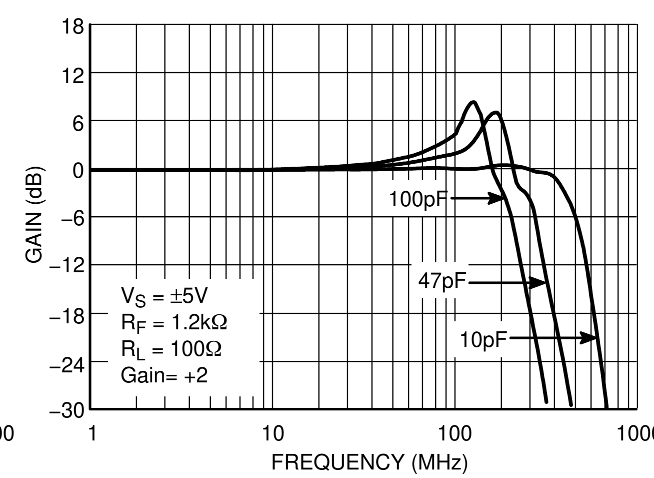


Figure 22. Frequency Response vs. CL

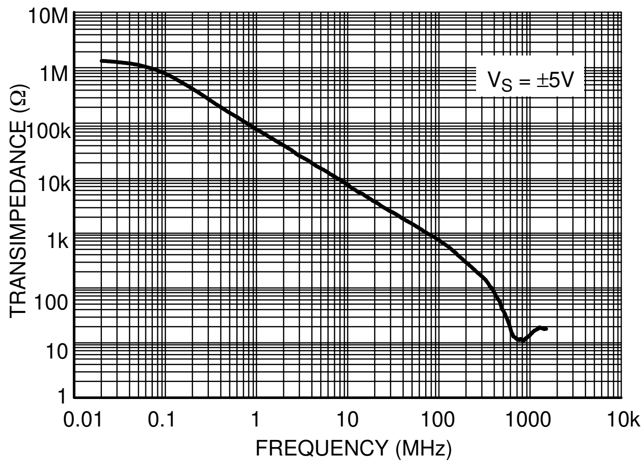


Figure 23. Transimpedance (ROL) vs. Frequency

General Design Considerations

The current feedback amplifier is optimized for use in high performance video and data acquisition systems. For current feedback architecture, its closed−loop bandwidth depends on the value of the feedback resistor. The closed−loop bandwidth is not a strong function of gain, as is for a voltage feedback amplifier, as shown in Figure 24.

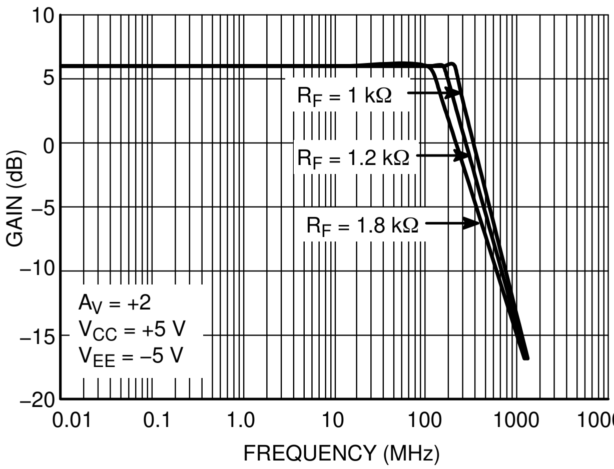


Figure 24. Frequency Response vs. R_F

The −3.0 dB bandwidth is, to some extent, dependent on the power supply voltages. By using lower power supplies, the bandwidth is reduced, because the internal capacitance increases. Smaller values of feedback resistor can be used at lower supply voltages, to compensate for this affect.

Feedback and Gain Resistor Selection for Optimum Frequency Response

A current feedback operational amplifier’s key advantage is the ability to maintain optimum frequency response independent of gain by using appropriate values for the feedback resistor. To obtain a very flat gain response, the feedback resistor tolerance should be considered as well. Resistor tolerance of 1% should be used for optimum flatness. Normally, lowering RF resistor from its recommended value will peak the frequency response and extend the bandwidth while increasing the value of RF resistor will cause the frequency response to roll off faster. Reducing the value of RF resistor too far below its recommended value will cause overshoot, ringing, and eventually oscillation.

Since each application is slightly different, it is worth some experimentation to find the optimal RF for a given circuit. A value of the feedback resistor that produces ∼0.1 dB of peaking is the best compromise between stability and maximal bandwidth. It is not recommended to use a current feedback amplifier with the output shorted directly to the inverting input.

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

This device is protected against electrostatic discharge (ESD) on all pins as specified in the attributes table. Note: Human Body Model for +IN and −IN pins are rated at 0.8 kV while all other pins are rated at 2.0 kV. 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.

ORDERING INFORMATION

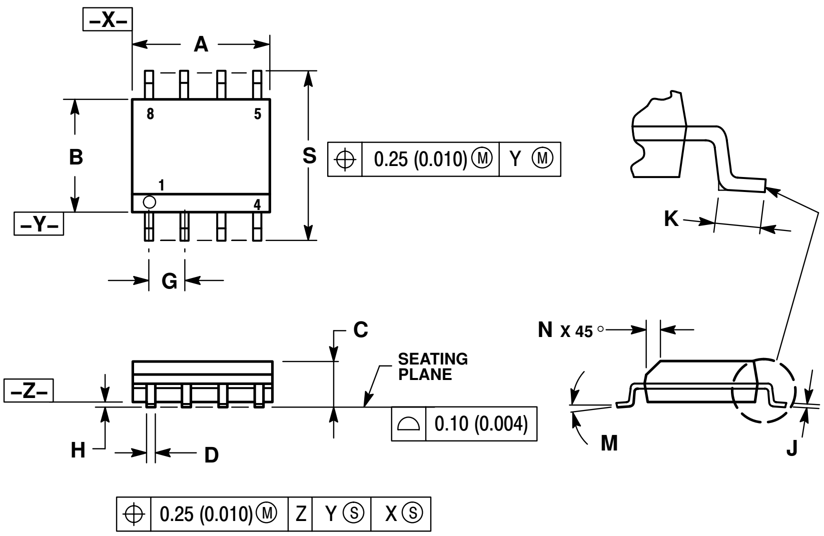
Device	Package	Shipping†
NCS2500SQT2	SC70−5 (SC88A)	3000 Tape & Reel
NCS2500SQT2G	SC70−5 (SC88A) (Pb−Free)	3000 Tape & Reel
NCS2500SNT1	SOT23−5 (TSOP−5)	3000 Tape & Reel
NCS2500SNT1G	SOT23−5 (TSOP−5) (Pb−Free)	3000 Tape & Reel
NCS2500D*	SO−8	98 Units/Rail
NCS2500DR2*	SO−8	2500 Tape & Reel
NCS2500DG*	SO−8 (Pb−Free)	98 Units/Rail
NCS2500DR2G*	SO−8 (Pb−Free)	2500 Tape & Reel

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

*Contact ON Semiconductor for ordering information.

PACKAGE DIMENSIONS

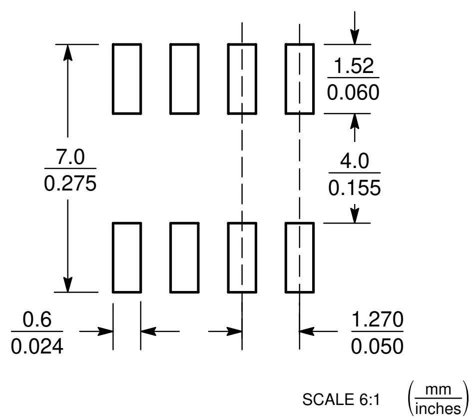
SO−8
D SUFFIX
CASE 751−07
ISSUE AF



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751−01 THRU 751−06 ARE OBSOLETE. NEW STANDARD IS 751−07.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

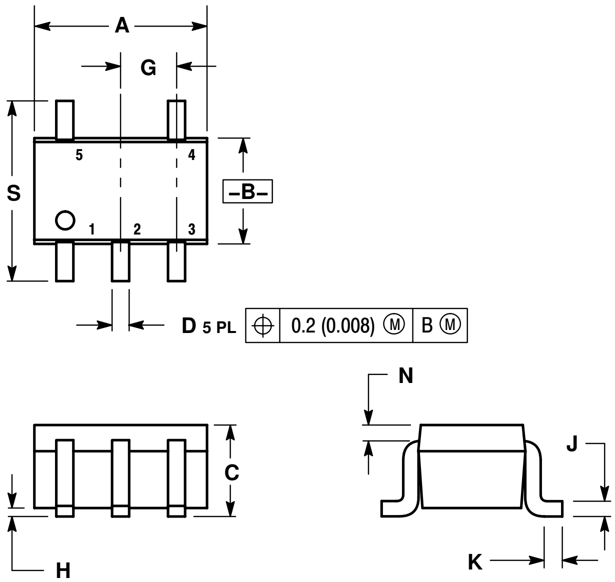
SOLDERING FOOTPRINT*



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

PACKAGE DIMENSIONS

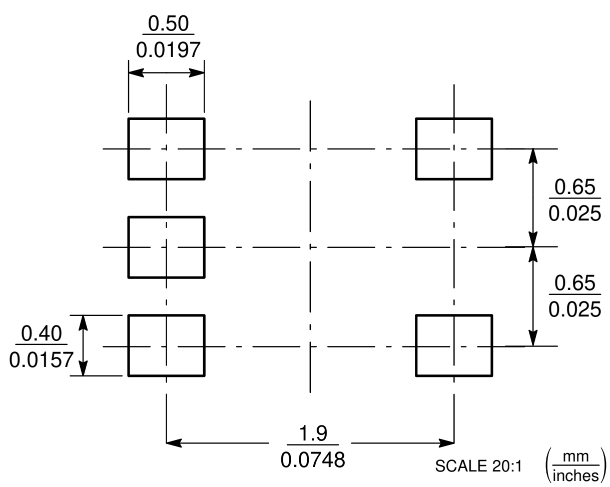
SC−70−5 (SC−88A)
SQ SUFFIX
CASE 419A−02
ISSUE G



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 419A−01 OBSOLETE. NEW STANDARD 419A−02.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.071	0.087	1.80	2.20
B	0.045	0.053	1.15	1.35
C	0.031	0.043	0.80	1.10
D	0.004	0.012	0.10	0.30
G	0.026 BSC		0.65 BSC	
H	---	0.004	---	0.10
J	0.004	0.010	0.10	0.25
K	0.004	0.012	0.10	0.30
N	0.008 REF		0.20 REF	
S	0.079	0.087	2.00	2.20

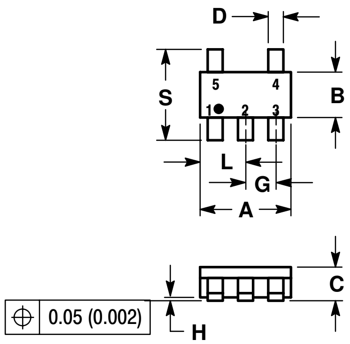
SOLDERING FOOTPRINT*

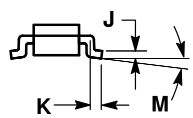


*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

SOT23−5 (TSOP−5)
SN SUFFIX
CASE 483−02
ISSUE C





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.

	MILLIMETERS		INCHES	
DIM	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

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