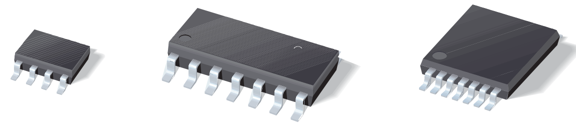


SLOS382 − SEPTEMBER 2001

LOW-NOISE, HIGH-SPEED, 450 mA CURRENT FEEDBACK AMPLIFIERS

FEATURES

- **Low Noise**
  - **2.9 pA/√Hz Noninverting Current Noise**
  - **10.8 pA/√Hz Inverting Current Noise**
  - **2.2 nV/√Hz Voltage Noise**
- **High Output Current, 450 mA**
- **High Speed**
  - **128 MHz , −3 dB BW(R_L = 50 Ω, R_F = 470 Ω)**
  - **1550 V/μs Slew Rate (G = 2, R_L = 50 Ω)**
- **Wide Output Swing**
  - **26 V_{PP} Output Voltage, R_L = 50 Ω**
- **Low Distortion**
  - **-80 dBc (1 MHz, 2 V_{PP}, G = 2)**
- **Low Power Shutdown Mode (THS3125)**
  - **370-μA Shutdown Supply Current**
- **Standard SOIC, SOIC PowerPAD™, and TSSOP PowerPAD Package**

APPLICATIONS

- **Video Distribution**
- **Instrumentation**
- **Line Drivers**
- **Motor Drivers**
- **Piezo Drivers**

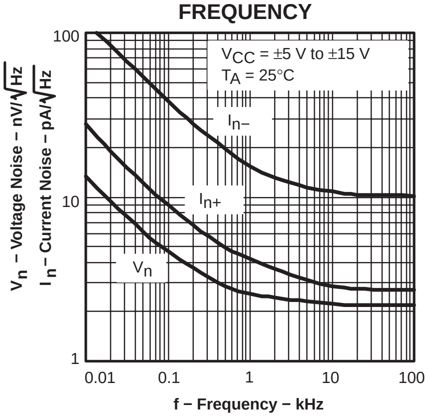
DESCRIPTION

The THS3122/5 are low-noise, high-speed current feedback amplifiers, with high output current drive. This makes them ideal for any application that requires low distortion over a wide frequency with heavy loads. The THS3122/5 can drive four serially terminated video lines while maintaining a differential gain error less than 0.03%.

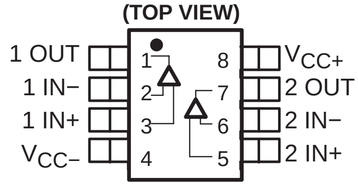
The high output drive capability of the THS3122/5 enables the devices to drive 50-Ω loads with low distortion over a wide range of output voltages:
−80 −dBc THD at 2 V_{PP}
−75 −dBc THD at 8 V_{PP}

The THS3122/5 can operate from ±5 V to ±15 V supply voltages while drawing as little as 7.2 mA of supply current per channel. They offer a low power shutdown mode, reducing the supply current to only 370 μA. The THS3122/5 are packaged in a standard SOIC, SOIC PowerPAD™, and TSSOP PowerPAD packages.

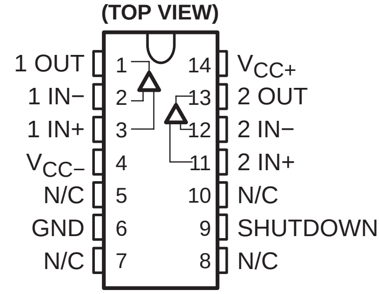
VOLTAGE NOISE AND CURRENT NOISE vs FREQUENCY



THS3122 SOIC (D) AND SOIC PowerPAD™ (DDA) PACKAGE (TOP VIEW)



THS3125 SOIC (D) AND TSSOP PowerPAD™ (PWP) PACKAGE (TOP VIEW)



AVAILABLE OPTIONS

T_A	PACKAGED DEVICE				EVALUATION MODULES
	SOIC-8 (D)	SOIC-8 PowerPAD (DDA)	SOIC-14 (D)	TSSOP-14 (PWP)	
0°C to 70°C	THS3122CD	THS3122CDDA	THS3125CD	THS3125CPWP	THS3122EVM THS3125EVM
−40°C to 85°C	THS3122ID	THS3122IDDA	THS3125ID	THS3125IPWP	

absolute maximum ratings over operating free-air temperature (unless otherwise noted)†

- Supply voltage, V_{CC+} to V_{CC-} . . . . . 33 V
- Input voltage . . . . . ± V_{CC}
- Output current (see Note 1) . . . . . 275 mA
- Differential input voltage . . . . . ± 4 V
- Maximum junction temperature . . . . . 150°C
- Total power dissipation at (or below) 25°C free-air temperature . . . . . See Dissipation Ratings Table
- Operating free-air temperature, T_A: Commercial . . . . . 0°C to 70°C
  - Industrial . . . . . −40°C to 85°C
- Storage temperature, T_{stg} : Commercial . . . . . −65°C to 125°C
  - Industrial . . . . . −65°C to 125°C
- Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 300°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: The THS3122 and THS3125 may incorporate a PowerPAD™ on the underside of the chip. This acts as a heatsink and must be connected to a thermally dissipating plane for proper power dissipation. Failure to do so may result in exceeding the maximum junction temperature which could permanently damage the device. See TI Technical Brief SLMA002 for more information about utilizing the PowerPAD™ thermally enhanced package.

DISSIPATION RATING TABLE

PACKAGE	θ_{JA}	T_A = 25°C POWER RATING
D-8	95°C/W‡	1.32 W
DDA	67°C/W	1.87 W
D-14	66.6°C/W‡	1.88 W
PWP	37.5°C/W	3.3 W

‡ This data was taken using the JEDEC proposed high-K test PCB. For the JEDEC low-K test PCB, the θ_{JA} is168°C/W for the D-8 package and 122.3°C/W for the D-14 package.

recommended operating conditions

		MIN	NOM	MAX	UNIT
Supply voltage, V_{CC+} to V_{CC-}	Dual supply	±5		±15	V
	Single supply	10		30	
Operating free-air temperature, T_A	C-suffix	0		70	°C
	I-suffix	−40		85	
Shutdown pin input levels, relative to the GND pin	High level (device shutdown)	2			V
	Low level (device active)			0.8	

electrical characteristics over recommended operating free-air temperature range, T_A = 25°C, V_{CC} = ±15 V, R_F= 750 Ω, R_L = 100 Ω (unless otherwise noted)

dynamic performance

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
BW	Small-signal bandwidth (−3 dB)	R_L = 50 Ω	R_F = 50 Ω, G = 1	V_{CC} = ±5 V		138		MHz
				V_{CC} = ±15 V		160		
		R_L = 50 Ω	R_F =470 Ω, G = 2	V_{CC} = ±5 V		126		
				V_{CC} = ±15 V		128		
	Bandwidth (0.1 dB)		R_F = 470 Ω, G = 2	V_{CC} = ±5 V		20		
				V_{CC} = ±15 V		30		
	Full power bandwidth	G = −1	$V_{O(PP)}$ = 4 V	V_{CC} = ±5 V		47		MHz
			$V_{O(pp)}$ = 20 V	V_{CC} = ±15 V		64		
SR	Slew rate (see Note 2), G=8	G = 2, R_F = 680 Ω	V_O = 10 V_{PP}	V_{CC} = ±15 V		1550		V/µs
			V_O = 5 V_{PP}	V_{CC} = ±5 V		500		
				V_{CC} = ±15 V		1000		
t_s	Settling time to 0.1%	G = −1	V_O = 2 V_{PP}	V_{CC} = ±5 V		53		ns
			V_O = 5 V_{PP}	V_{CC} = ±15 V		64		

NOTE 2: Slew rate is defined from the 25% to the 75% output levels.

noise/distortion performance

PARAMETER			TEST CONDITIONS		MIN	TYP	MAX	UNIT
THD	Total harmonic distortion		G = 2, R_F = 470 Ω, V_{CC} = ±15 V, f = 1 MHz	$V_{O(PP)}$ = 2 V		−80		dBc
				$V_{O(PP)}$ = 8 V		−75		
			G = 2, R_F = 470 Ω, V_{CC} = ±5 V, f = 1 MHz	$V_{O(PP)}$ = 2 V		−77		
				$V_{O(PP)}$ = 5 V		−76		
V_n	Input voltage noise		V_{CC} = ±5 V, ±15 V	f = 10 kHz		2.2		nV/√Hz
I_n	Input current noise	Noninverting Input	V_{CC} = ±5 V, ±15 V	f = 10 kHz		2.9		pA/√Hz
		Inverting Input				10.8		
	Crosstalk		G = 2, f = 1 MHz, V_O = 2 V_{PP}	V_{CC} = ±5 V		−67		dBc
				V_{CC} = ±15 V		−67		
	Differential gain error		G = 2, R_L = 150 Ω, 40 IRE modulation, ±100 IRE Ramp, NTSC and PAL	V_{CC} = ±5 V		0.01%		
				V_{CC} = ±15 V		0.01%		
	Differential phase error			V_{CC} = ±5 V		0.011°		
				V_{CC} = ±15 V		0.011°		

electrical characteristics over recommended operating free-air temperature range, T_A = 25°C, V_{CC} = ±15 V, R_F = 750 Ω, R_L = 100 Ω (unless otherwise noted) (continued)

dc performance

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	V_{IC} = 0 V, V_O = 0 V, V_{CC} = ±5 V, V_{CC} = ±15 V	T_A = 25°C		4.4	6	mV
			T_A = full range			8	
	Channel offset voltage matching		T_A = 25°C		0.4	2	
			T_A = full range			3	
	Offset drift		T_A = full range		10		µV/°C
I_{IB}	IN− Input bias current	V_{IC} = 0 V, V_O = 0 V, V_{CC} = ±5 V, V_{CC} = ±15 V	T_A = 25°C		6	23	µA
			T_A = full range			30	
	IN+ Input bias current		T_A = 25°C		0.33	2	
			T_A = full range			3	
I_{IO}	Input offset current	V_{IC} = 0 V, V_O = 0 V, V_{CC} = ±5 V, V_{CC} = ±15 V	T_A = 25°C		5.4	22	µA
			T_A = full range			30	
Z_{OL}	Open loop transimpedance	V_{CC} = ±5 V, V_{CC} = ±15 V	R_L = 1 kΩ,		1		MΩ

input characteristics

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{ICR}	Input common-mode voltage range	V_{CC} = ±5 V	T_A = full range	±2.5	±2.7		V
		V_{CC} = ±15 V		±12.5	±12.7		
CMRR	Common-mode rejection ratio	V_{CC} = ±5 V, V_I = −2.5 V to 2.5 V	T_A = 25°C	58	62		dB
			T_A = full range	56			
		V_{CC} = ±15 V, V_I = −12.5 V to 12.5 V	T_A = 25°C	63	67		
			T_A = full range	60			
R_I	Input resistance	IN+			1.5		MΩ
		IN−			15		Ω
C_i	Input capacitance				2		pF

output characteristics

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
V_O	Output voltage swing	G = 4, V_I = 1.06 V, V_{CC} = ±5 V	R_L = 1 kΩ,	T_A = 25°C		4.1		V
		G = 4, V_I = 1.025 V, V_{CC} = ±5 V	R_L = 50 Ω,	T_A = 25°C	3.8	4		V
				T_A = full range	3.7			
		G = 4, V_I = 3.6 V, V_{CC} = ±15 V	R_L = 1 kΩ,	T_A = 25°C		14.2		
		G = 4, V_I = 3.325 V, V_{CC} = ±15 V	R_L = 50 Ω,	T_A = 25°C	12	13.3		V
				T_A = full range	11.5			
I_O	Output current drive	G = 4, V_I = 1.025 V, V_{CC} = ±5 V	R_L = 10 Ω,	T_A = 25°C	200	280		mA
		G = 4, V_I = 3.325 V, V_{CC} = ±15 V	R_L = 25 Ω,	T_A = 25°C	360	440		mA
r_o	Output resistance		open loop	T_A = 25°C		14		Ω

electrical characteristics over recommended operating free-air temperature range, T_A = 25°C, V_{CC} = ±15 V, R_F = 750 Ω, R_L = 100 Ω (unless otherwise noted) (continued)

power supply

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
I_{CC}	Quiescent current (per channel)	V_{CC} = ±5V	T_A = 25°C		7.2	9	mA
			T_A = full range			10	
		V_{CC} = ±15 V	T_A = 25°C		8.4	10.5	
			T_A = full range			11.5	
PSRR	Power supply rejection ratio	V_{CC} = ±5 V ±1 V	T_A = 25°C	53	60		dB
			T_A = full range	50			
		V_{CC} = ±15 V ±1 V	T_A = 25°C	68	73		
			T_A = full range	66			

shutdown characteristics (THS3125 only)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$I_{CC(SHDN)}$	Shutdown quiescent current (per channel)	GND = 0 V, V_{CC} = ±5 V to ±15 V	$V_{(SHDN)}$ = 3.3 V		370	500	µA
t_{DIS}	Disable time (see Note 3)				200		ns
t_{EN}	Enable time (see Note 3)				500		ns
$I_{IL(SHDN)}$	Shutdown pin low level leakage current		$V_{(SHDN)}$ = 0 V		18	25	µA
$I_{IH(SHDN)}$	Shutdown pin high level leakage current		$V_{(SHDN)}$ = 3.3 V		110	130	µA

NOTE 3: Disable/enable time is defined as the time from when the shutdown signal is applied to the SHDN pin to when the supply current has reached half of its final value.

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
	Small signal closed loop gain	vs Frequency	1 − 10
	Small and large signal output	vs Frequency	11, 12
	Harmonic distortion	vs Frequency	13, 14, 15
		vs Peak−to−peak output voltage	16, 17
V_n, I_n	Voltage noise and current noise	vs Frequency	18
CMRR	Common-mode rejection ratio	vs Frequency	19
	Crosstalk	vs Frequency	20
Z_o	Output impedance	vs Frequency	21
SR	Slew rate	vs Output voltage step	22
V_{IO}	Input offset voltage	vs Free-air temperature	23
		vs Common-mode input voltage	24
I_B	Input bias current	vs Free-air temperature	25
V_O	Output voltage	vs Load current	26
	Quiescent current	vs Free-air temperature	27
		vs Supply voltage	28
I_{CC}	Shutdown supply current	vs Free-air temperature	29
	Differential gain and phase error	vs 75 Ω serially terminated loads	30, 31
	Shutdown response		32
	Small signal pulse response		33, 34
	Large signal pulse response		35, 36

TYPICAL CHARACTERISTICS

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

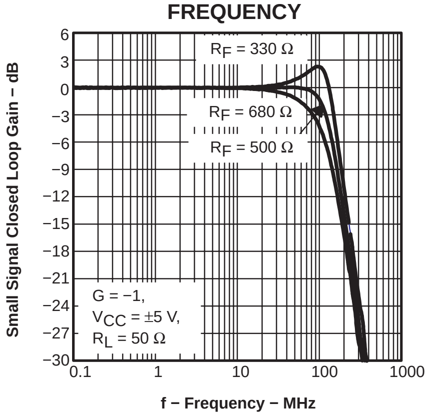


Figure 1

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

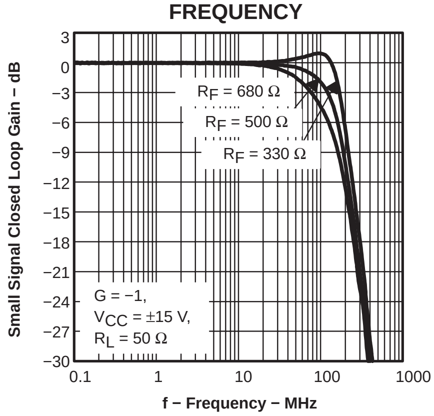


Figure 2

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

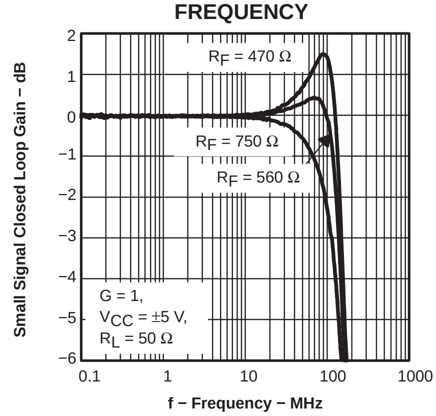


Figure 3

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

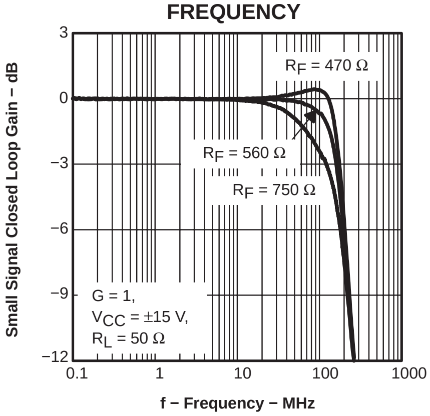


Figure 4

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

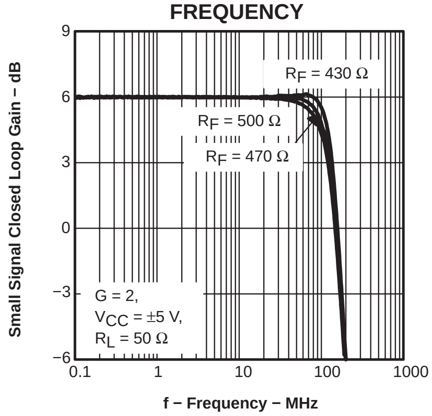


Figure 5

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

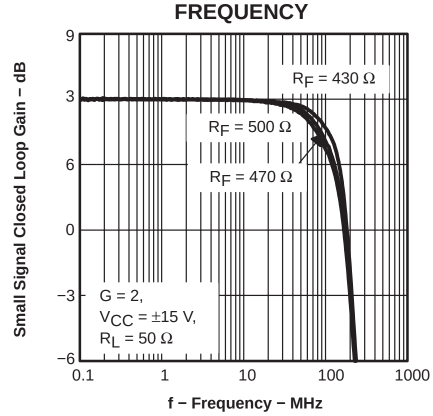


Figure 6

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

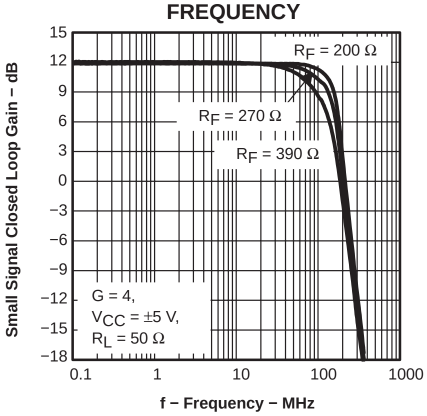


Figure 7

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

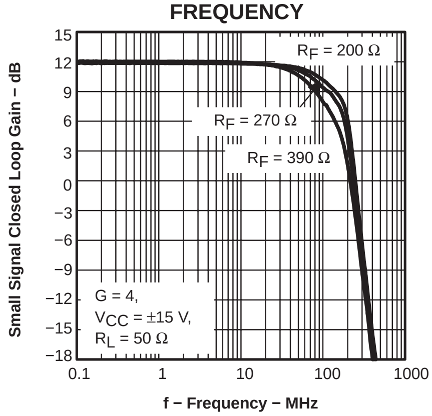


Figure 8

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

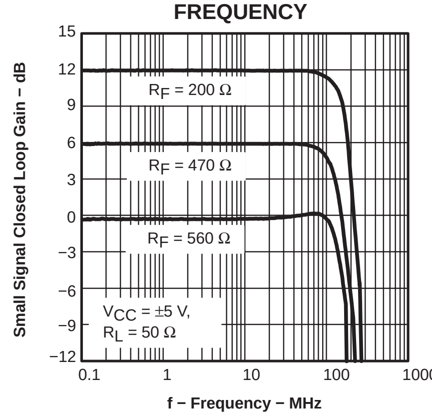


Figure 9

TYPICAL CHARACTERISTICS

SMALL SIGNAL CLOSED LOOP GAIN vs FREQUENCY

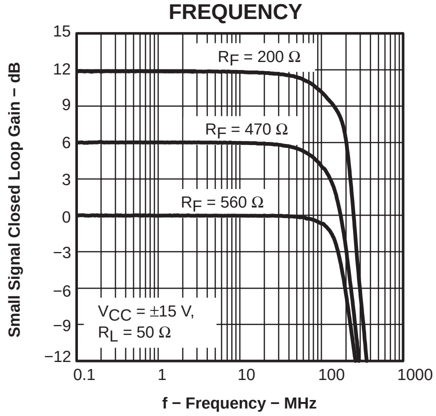


Figure 10

SMALL AND LARGE SIGNAL OUTPUT vs FREQUENCY

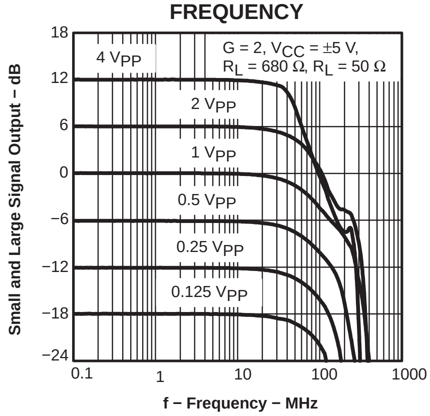


Figure 11

SMALL AND LARGE SIGNAL OUTPUT vs FREQUENCY

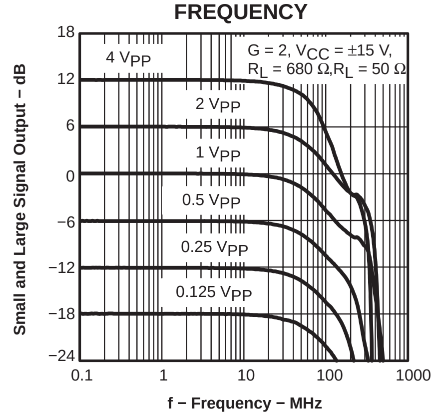


Figure 12

HARMONIC DISTORTION vs FREQUENCY

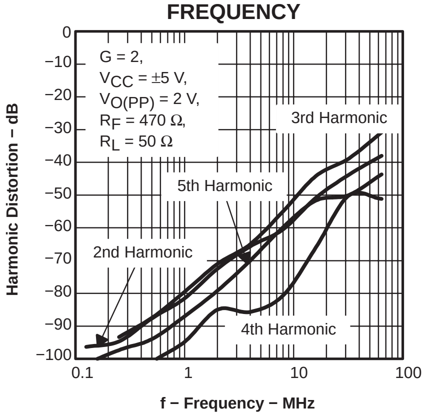


Figure 13

HARMONIC DISTORTION vs FREQUENCY

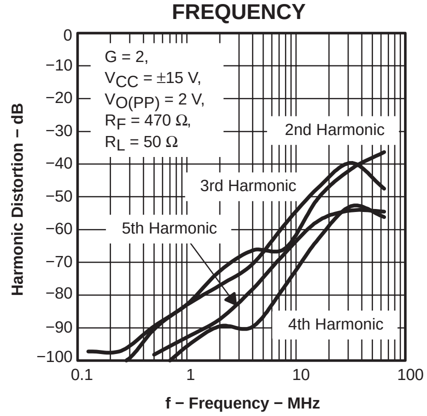


Figure 14

HARMONIC DISTORTION vs FREQUENCY

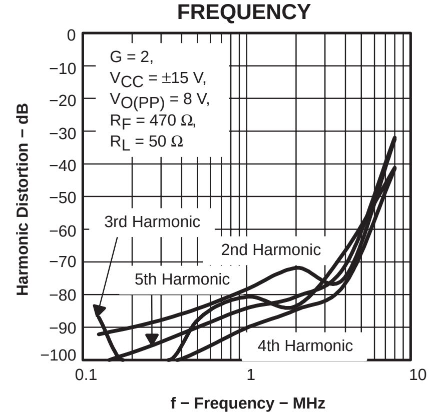


Figure 15

HARMONIC DISTORTION vs PEAK-TO-PEAK OUTPUT VOLTAGE

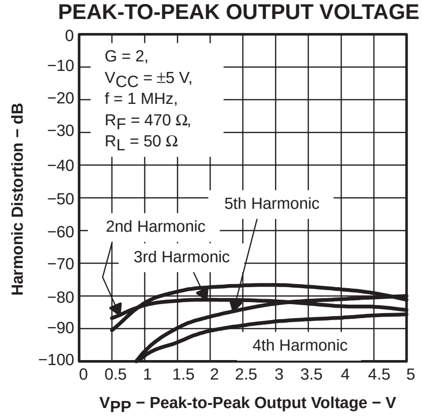


Figure 16

HARMONIC DISTORTION vs PEAK-TO-PEAK OUTPUT VOLTAGE

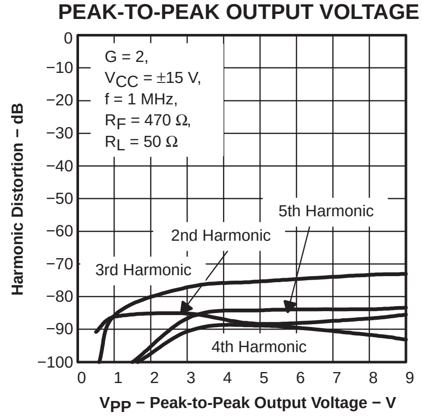


Figure 17

VOLTAGE NOISE AND CURRENT NOISE vs FREQUENCY

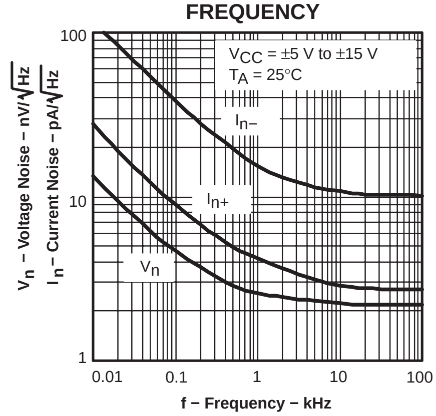


Figure 18

TYPICAL CHARACTERISTICS

COMMON-MODE REJECTION RATIO vs FREQUENCY

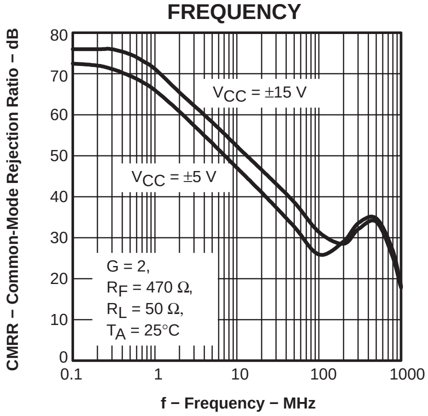


Figure 19

CROSSTALK vs FREQUENCY

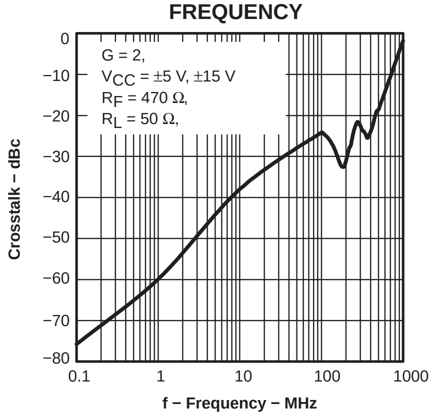


Figure 20

OUTPUT IMPEDANCE vs FREQUENCY

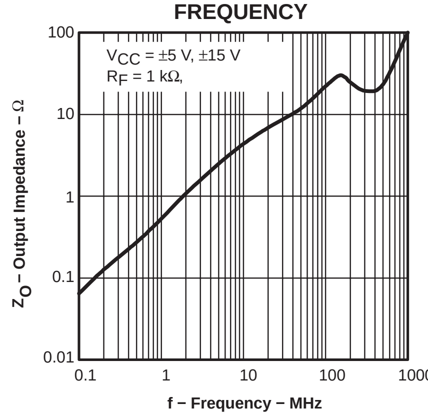


Figure 21

SLEW RATE vs OUTPUT VOLTAGE STEP

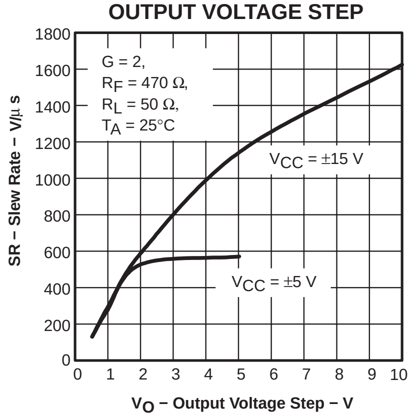


Figure 22

INPUT OFFSET VOLTAGE vs FREE-AIR TEMPERATURE

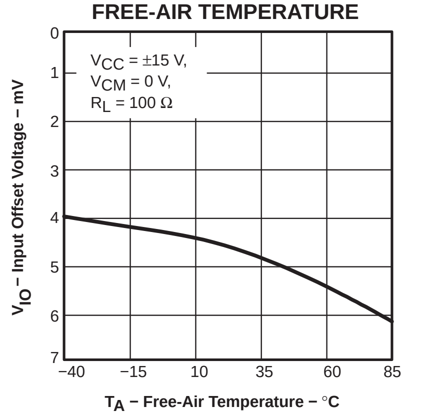


Figure 23

INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE

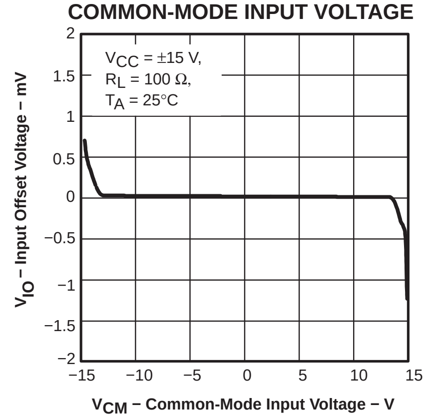


Figure 24

INPUT BIAS CURRENT vs FREE-AIR TEMPERATURE

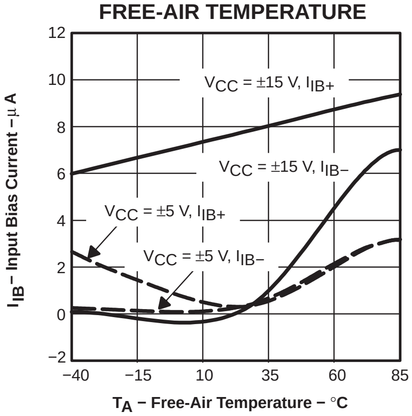


Figure 25

OUTPUT VOLTAGE vs LOAD CURRENT

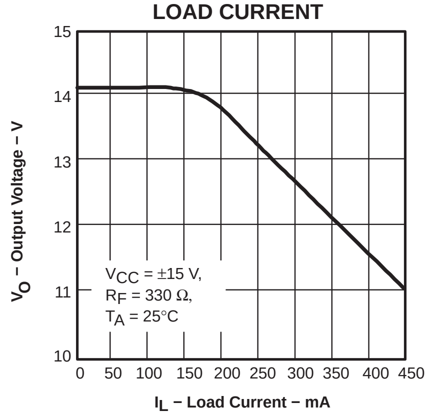


Figure 26

QUIESCENT CURRENT vs FREE-AIR TEMPERATURE

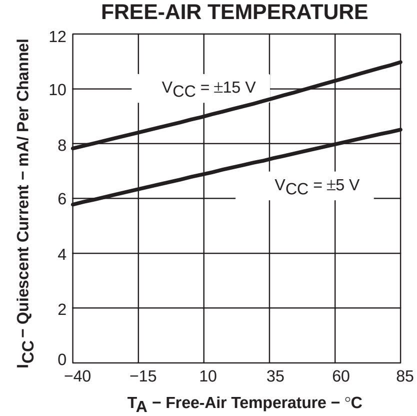


Figure 27

TYPICAL CHARACTERISTICS

QUIESCENT CURRENT
vs
SUPPLY VOLTAGE

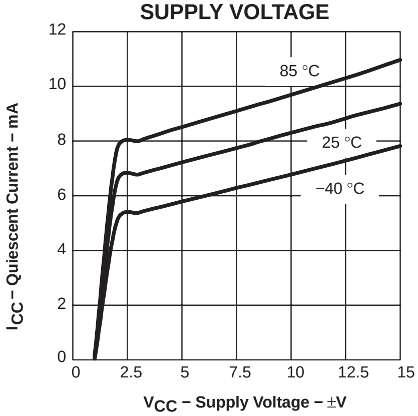


Figure 28

SHUTDOWN SUPPLY CURRENT
vs
FREE-AIR TEMPERATURE

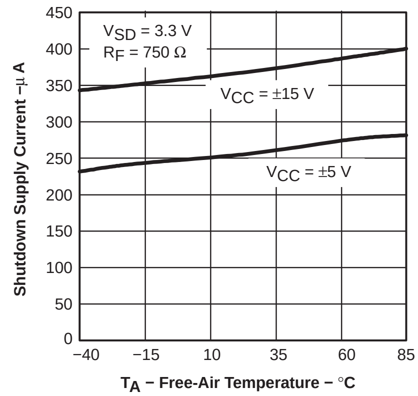


Figure 29

DIFFERENTIAL PHASE AND GAIN ERROR
vs
75 Ω SERIALLY TERMINATED LOADS

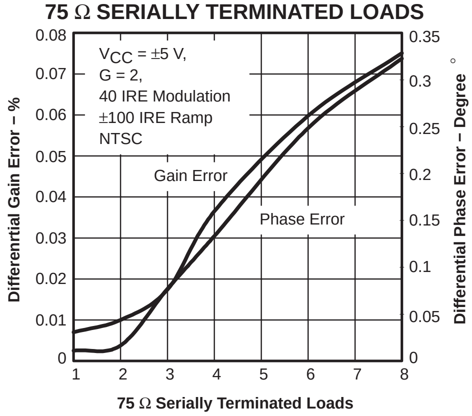


Figure 30

DIFFERENTIAL PHASE AND GAIN ERROR
vs
75 Ω SERIALLY TERMINATED LOADS

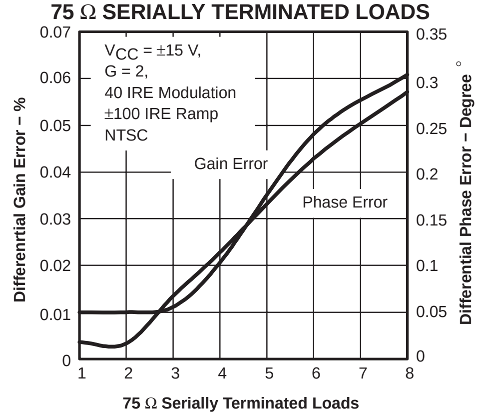


Figure 31

THS3125
SHUTDOWN RESPONSE

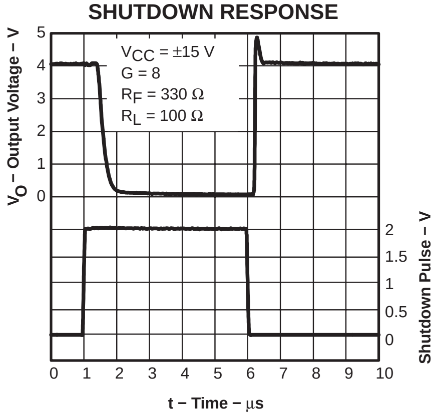


Figure 32

SMALL SIGNAL PULSE RESPONSE

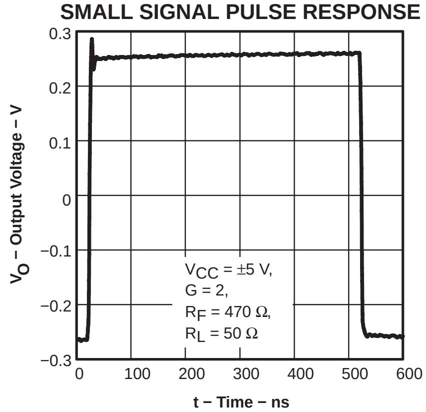


Figure 33

SMALL SIGNAL PULSE RESPONSE

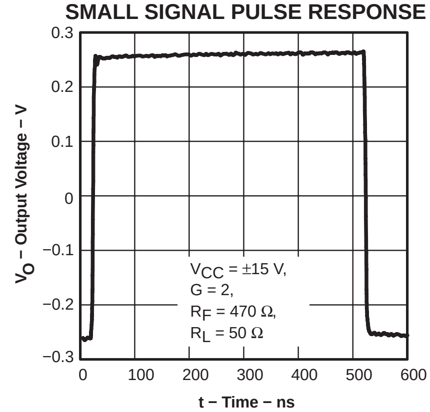


Figure 34

TYPICAL CHARACTERISTICS

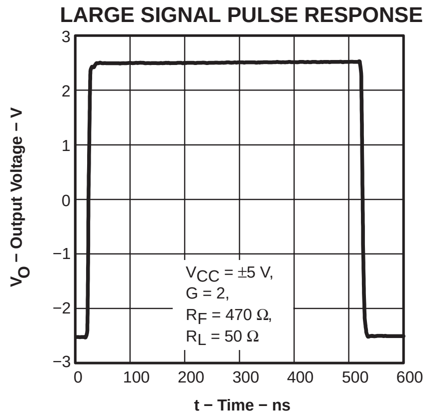


Figure 35

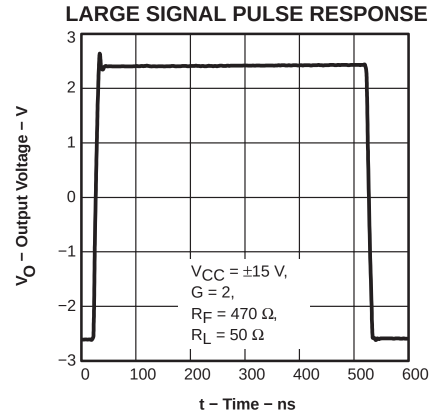
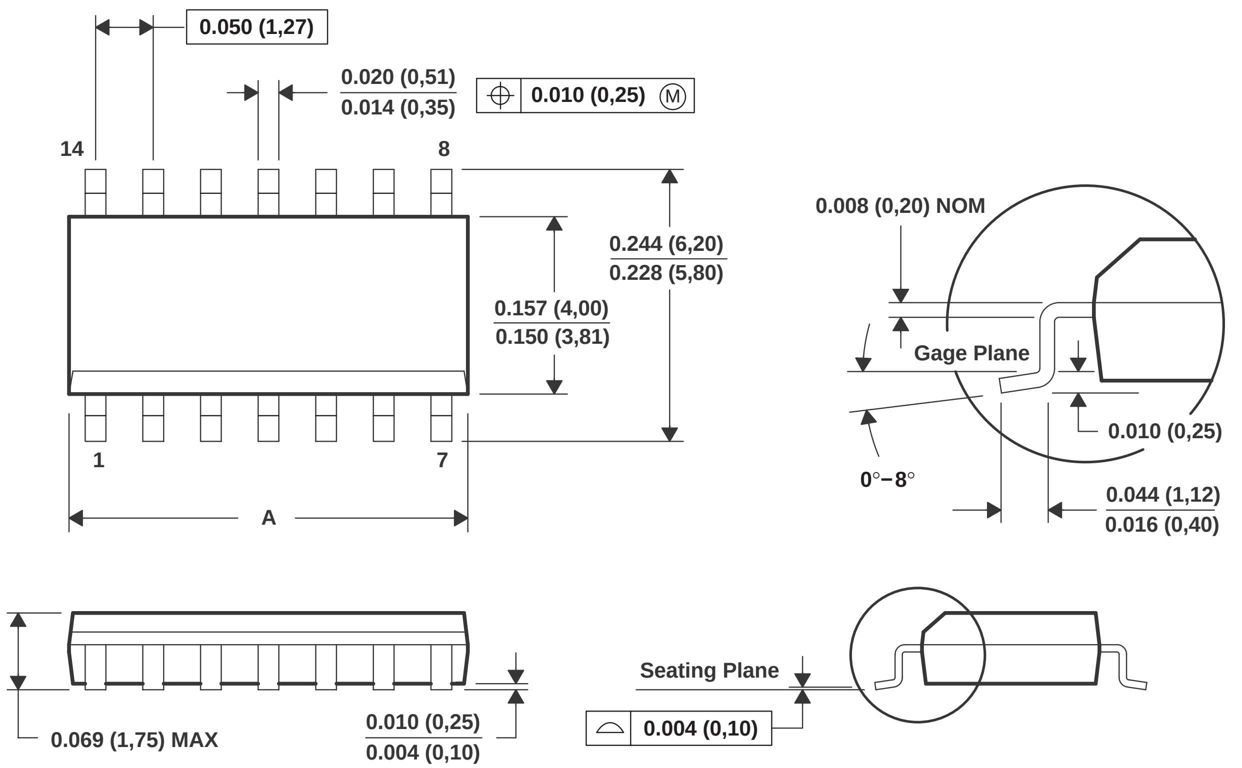


Figure 36

MECHANICAL DATA

D (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PINS SHOWN



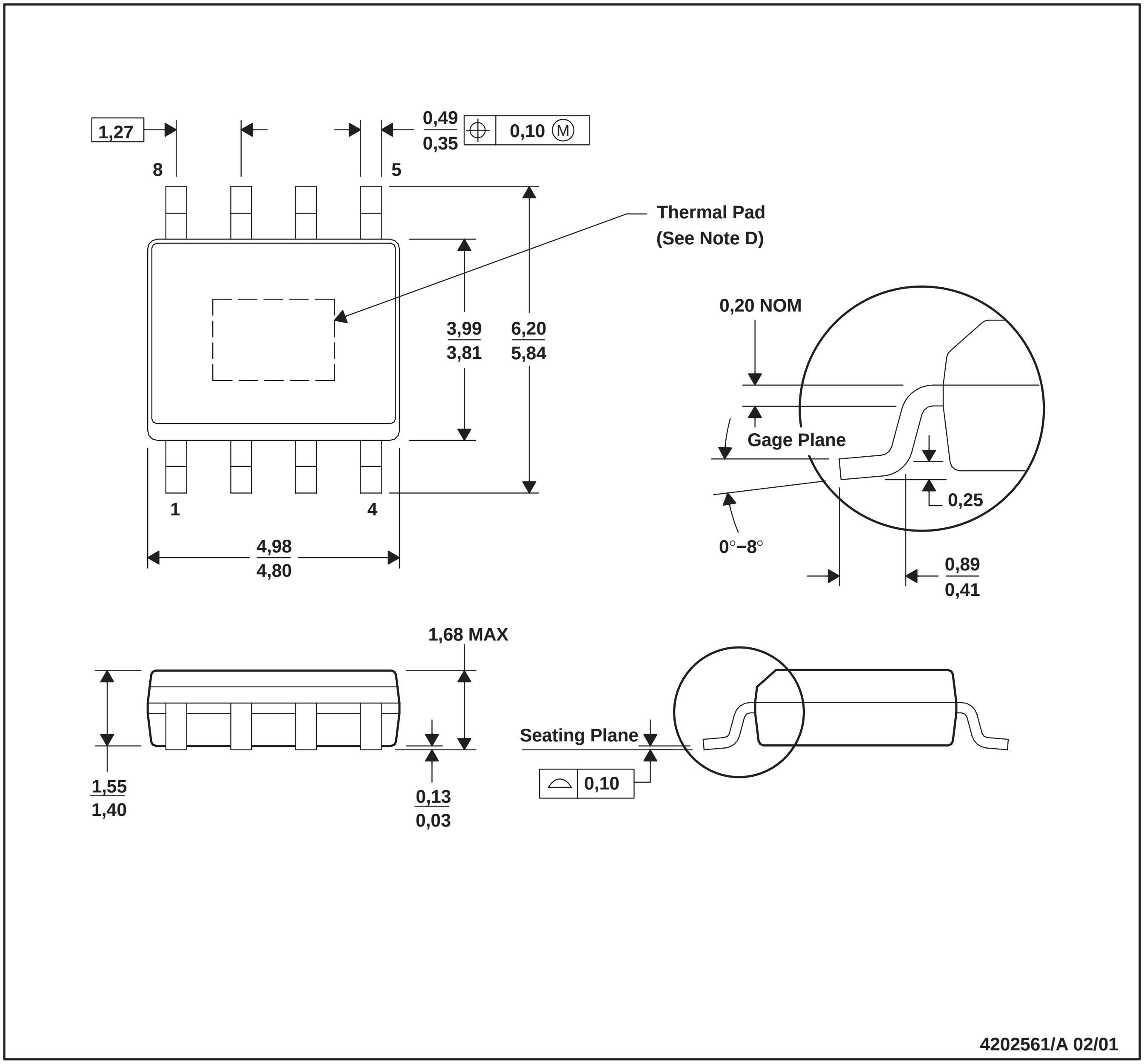
DIM \ PINS **	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

4040047 / D 10/96

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012

MECHANICAL INFORMATION

DDA (S−PDSO−G8) **Power PAD™ PLASTIC SMALL-OUTLINE**



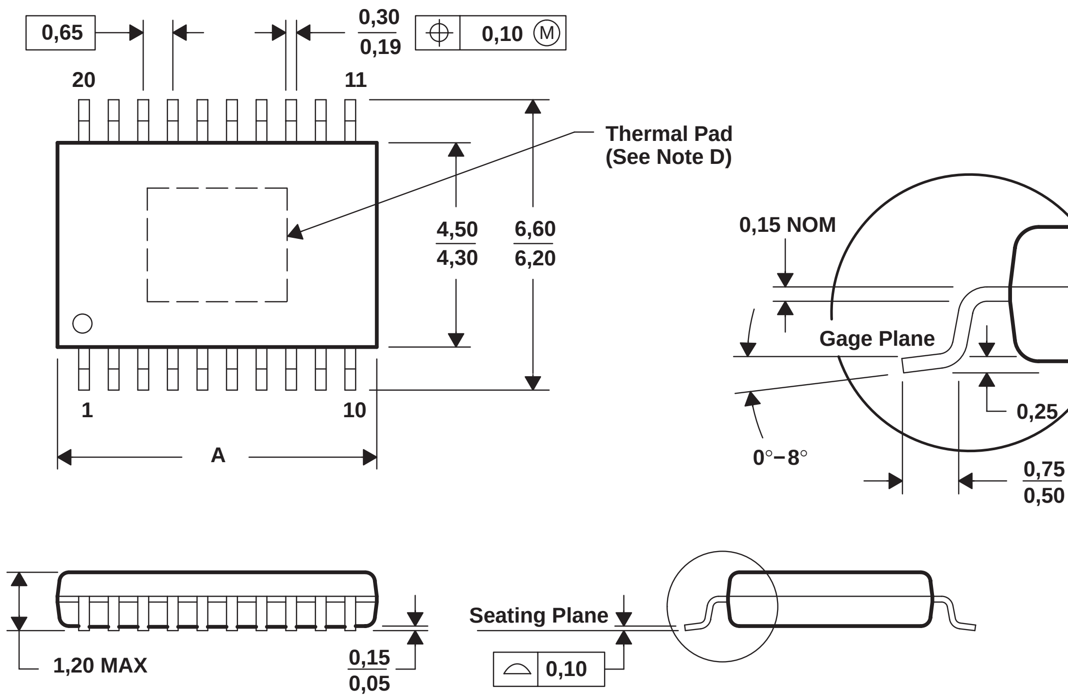
NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. The package thermal performance may be enhanced by bonding the thermal pad to an external thermal plane. This pad is electrically and thermally connected to the backside of the die and possibly selected leads.

PowerPAD is a trademark of Texas Instruments.

MECHANICAL INFORMATION

PWP (R-PDSO-G)** **PowerPAD™ PLASTIC SMALL-OUTLINE PACKAGE**

20-PIN SHOWN



PINS ** / DIM	14	16	20	24	28
A MAX	5,10	5,10	6,60	7,90	9,80
A MIN	4,90	4,90	6,40	7,70	9,60

4073225/E 03/97

NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusions.
- D. The package thermal performance may be enhanced by bonding the thermal pad to an external thermal plane. This pad is electrically and thermally connected to the backside of the die and possibly selected leads.
- E. Falls within JEDEC MO-153

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
THS3122CD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
THS3122CDDA	ACTIVE	SO Power PAD	DDA	8	75	None	CU SNPB	Level-1-235C-UNLIM
THS3122CDDAR	ACTIVE	SO Power PAD	DDA	8	2500	None	CU SNPB	Level-1-235C-UNLIM
THS3122CDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
THS3122ID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
THS3122IDDA	ACTIVE	SO Power PAD	DDA	8	75	None	CU SNPB	Level-1-235C-UNLIM
THS3122IDDAR	ACTIVE	SO Power PAD	DDA	8	2500	None	CU SNPB	Level-1-235C-UNLIM
THS3122IDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
THS3125CD	ACTIVE	SOIC	D	14	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
THS3125CDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
THS3125CPWP	ACTIVE	HTSSOP	PWP	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
THS3125CPWPR	ACTIVE	HTSSOP	PWP	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
THS3125ID	ACTIVE	SOIC	D	14	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
THS3125IDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
THS3125IPWP	ACTIVE	HTSSOP	PWP	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
THS3125IPWPR	ACTIVE	HTSSOP	PWP	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
None: Not yet available Lead (Pb-Free).
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDECindustry standard classifications, and peak solder temperature.

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