

# THS7530 High-Speed, Fully Differential, Continuously Variable Gain Amplifier

## 1 Features

- Low Noise:  $V_n = 1.1 \text{ nV}/\sqrt{\text{Hz}}$ , Noise Figure = 9 dB
- Low Distortion:
  - $\text{HD}_2 = -65 \text{ dBc}$ ,  $\text{HD}_3 = -61 \text{ dBc}$  at 32 MHz
  - $\text{IMD}_3 = -62 \text{ dBc}$ ,  $\text{OIP}_3 = 21 \text{ dBm}$  at 70 MHz
- 300-MHz Bandwidth
- Continuously Variable Gain Range: 11.6 dB to 46.5 dB
- Gain Slope: 38.8 dB/V
- Fully Differential Input and Output
- Output Common-Mode Voltage Control
- Output Voltage Limiting

## 2 Applications

- Time Gain Amplifiers in Ultra Sound, Sonar, and Radar
- Automatic Gain Control in Communication and Video
- System Gain Calibration in Communications
- Variable Gain in Instrumentation

## 3 Description

The THS7530 device is fabricated using Texas Instruments' state-of-the-art BiCom III SiGe complementary bipolar process. The THS7530 device is a DC-coupled, wide bandwidth amplifier with voltage-controlled gain. The amplifier has high-impedance differential inputs and low-impedance differential outputs with high-bandwidth gain control, output common-mode control, and output voltage clamping.

Signal-channel performance is exceptional with 300-MHz bandwidth, and third harmonic distortion of  $-61 \text{ dBc}$  at 32 MHz with  $1\text{-}V_{\text{PP}}$  output into  $400 \Omega$ .

Gain control is linear in dB with 0 V to 0.9 V varying the gain from 11.6 dB to 46.5 dB with 38.8-dB/V gain slope.

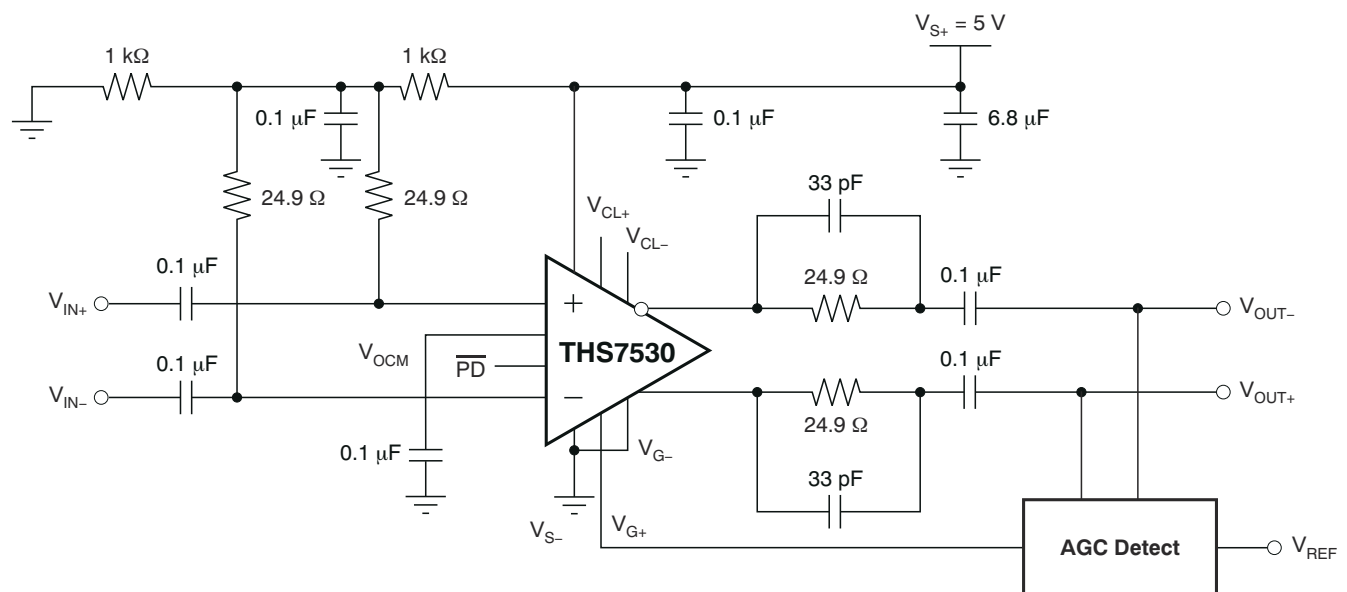
Output voltage limiting is provided to limit the output voltage swing and to prevent saturating following stages.

The device is characterized for operation over the industrial temperature range,  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ .

### Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
THS7530	HTSSOP (14)	5.00 mm × 4.40 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



**Typical Application Circuit**



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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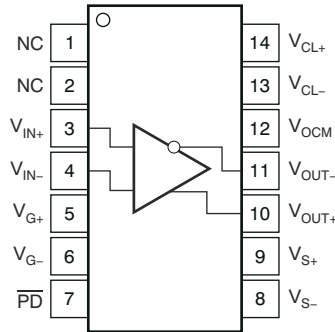
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## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Revision D (July 2015) to Revision E (August 2020)</b>	<b>Page</b>
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	1
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<b>Changes from Revision C (February 2010) to Revision D (July 2015)</b>	<b>Page</b>
• Added <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section.....	1
<hr/>	
<b>Changes from Revision B (February 2006) to Revision C (February 2010)</b>	<b>Page</b>
• Corrected polarity indication on input and output in front-page figure.....	1
• Deleted <i>lead temperature</i> specification from <a href="#">Absolute Maximum Ratings</a> table.....	4
• Corrected <a href="#">Figure 7-2</a> .....	11
• Changed <a href="#">Figure 9-2</a> and <a href="#">Figure 9-3</a> to correct problem with output polarity indication.....	14
• Changed <a href="#">Figure 9-4</a> and <a href="#">Figure 9-5</a> to correct problem with output polarity indication.....	14

## 5 Pin Configuration and Functions



**Figure 5-1. PWP Package 14-Pin HTSSOP With PowerPAD™ Top View**

### Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
NC	1	—	No internal connection
	2		
$\overline{\text{PD}}$	7	—	Power down, $\overline{\text{PD}}$ = logic low puts the device into low power mode; $\overline{\text{PD}}$ = logic high or open for normal operation
$V_{\text{CL-}}$	13	I	Output negative clamp voltage input
$V_{\text{CL+}}$	14	I	Output positive clamp voltage input
$V_{\text{G-}}$	6	I	Gain setting negative input
$V_{\text{G+}}$	5	I	Gain setting positive input
$V_{\text{IN-}}$	4	I	Inverting amplifier input
$V_{\text{IN+}}$	3	I	Noninverting amplifier input
$V_{\text{OCM}}$	12	I	Output common-mode voltage input
$V_{\text{OUT-}}$	11	O	Inverted amplifier output
$V_{\text{OUT+}}$	10	O	Noninverted amplifier output
$V_{\text{S-}}$	8	I	Negative amplifier power-supply input
$V_{\text{S+}}$	9	I	Positive amplifier power-supply input

## 6 Specifications

### 6.1 Absolute Maximum Ratings

Over operating free-air temperature range, unless otherwise noted.<sup>(1)</sup>

		MIN	MAX	UNIT
$V_{S+} - V_{S-}$	Supply voltage		5.5	V
$V_I$	Input voltage		$\pm V_S$	V
$I_O$	Output current		65	mA
$V_{ID}$	Differential input voltage		$\pm 4$	V
	Continuous power dissipation	See <a href="#">Section 6.4</a>		
$T_J$	Maximum junction temperature		150	°C
	Maximum junction temperature for long term stability <sup>(2)</sup>		125	°C
$T_{stg}$	Storage temperature	-65	150	°C

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The maximum junction temperature for continuous operation is limited by package constraints. Operation above this temperature may result in reduced reliability and/or lifetime of the device.

### 6.2 ESD Ratings

		VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	$\pm 3000$
		Charged device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	$\pm 1500$
		Machine model (MM)	$\pm 200$

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
$[V_{S-} \text{ to } V_{S+}]$	Supply voltage	4.5	5	5.5	V
	Input common mode voltage	$[V_{S-} \text{ to } V_{S+}] = 5 \text{ V}$		2.5	V
	Output common mode voltage	$[V_{S-} \text{ to } V_{S+}] = 5 \text{ V}$		2.5	V
$T_A$	Operating free-air temperature	-40		85	°C

### 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		THS7530	UNIT
		PWP (HTSSOP)	
		14 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	50.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	34.9	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	29	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	1.6	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	28.7	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	3.2	°C/W

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

## 6.5 Electrical Characteristics: Main Amplifier

$V_{S+} = 5\text{ V}$ ,  $V_{S-} = 0\text{ V}$ ,  $V_{OCM} = 2.5\text{ V}$ ,  $V_{ICM} = 2.5\text{ V}$ ,  $V_{G-} = 0\text{ V}$ ,  $V_{G+} = 1\text{ V}$  (maximum gain),  $T_A = 25^\circ\text{C}$ , AC performance measured using the AC test circuit shown in [Figure 7-1](#) (unless otherwise noted). DC performance is measured using the DC test circuit shown in [Figure 7-2](#) (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>AC PERFORMANCE</b>					
Small-signal bandwidth	All gains, $P_{IN} = -45\text{ dBm}$		300		MHz
Slew rate <sup>(1)</sup>	1- $V_{PP}$ Step, 25% to 75%, minimum gain		1250		V/ $\mu\text{s}$
Settling time to 1% <sup>(1)</sup>	1- $V_{PP}$ Step, minimum gain		11		ns
Harmonic distortion, 2nd harmonic	$f = 32\text{ MHz}$ , $V_{O(PP)} = 1\text{ V}$ , $R_{L(diff)} = 400\ \Omega$		-65		dBc
Harmonic distortion, 3rd harmonic	$f = 32\text{ MHz}$ , $V_{O(PP)} = 1\text{ V}$ , $R_{L(diff)} = 400\ \Omega$		-61		dBc
Third-order intermodulation distortion	$P_O = -10\text{ dBm}$ each tone, $f_C = 70\text{ MHz}$ , 200-kHz tone spacing		-62		dBc
Third-order output intercept point	$f_C = 70\text{ MHz}$ , 200-kHz tone spacing		21		dBm
Noise figure (with input termination)	Source impedance: $50\ \Omega$		9		dB
Total input voltage noise	$f > 100\text{ kHz}$		1.1		nV/ $\sqrt{\text{Hz}}$
<b>DC PERFORMANCE—INPUTS</b>					
Input bias current	$T_A = 25^\circ\text{C}$		20	39	$\mu\text{A}$
	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			40	
Input bias current offset			<150		pA
Minimum input voltage	Minimum gain, $T_A = 25^\circ\text{C}$		1.5	1.6	V
	Minimum gain, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			1.7	
Maximum input voltage	Minimum gain, $T_A = 25^\circ\text{C}$	3.35	3.5		V
	Minimum gain, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$	3.2			
Common-mode rejection ratio	$T_A = 25^\circ\text{C}$	56	114		dB
	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$	44			
Differential input impedance			$8.5 \parallel 3$		k $\Omega \parallel \mu\text{F}$
<b>DC PERFORMANCE—OUTPUTS</b>					
Output offset voltage	All gains, $T_A = 25^\circ\text{C}$		$\pm 100$	$\pm 340$	mV
	All gains, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			$\pm 480$	
Maximum output voltage high	$T_A = 25^\circ\text{C}$	3.275	3.5		V
	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$	3.25			
Minimum output voltage low	$T_A = 25^\circ\text{C}$		1.5	1.7	V
	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			1.8	
Output current	$T_A = 25^\circ\text{C}$	$\pm 16$	$\pm 37$		mA
	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$	$\pm 16$			
Output impedance			15		$\Omega$
<b>OUTPUT COMMON-MODE VOLTAGE CONTROL</b>					
Small-signal bandwidth			32		MHz
Gain			1		V/V
Common-mode offset voltage	$T_A = 25^\circ\text{C}$		4.5	12	mV
	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			13.8	
Minimum input voltage			1.75		V
Maximum input voltage			3.25		V
Input impedance			$25 \parallel 1$		k $\Omega \parallel \mu\text{F}$
Default voltage, with no connect			2.5		V
Input bias current			<1		$\mu\text{A}$
<b>GAIN CONTROL</b>					
Gain control differential voltage range	$V_{G+}$		0 to 1		V
Minus gain control voltage	$V_{G-} - V_{S-}$		-0.6 to 0.8		V
Minimum gain	$V_{G+} = 0\text{ V}$		11.6		dB

### 6.5 Electrical Characteristics: Main Amplifier (continued)

$V_{S+} = 5\text{ V}$ ,  $V_{S-} = 0\text{ V}$ ,  $V_{OCM} = 2.5\text{ V}$ ,  $V_{ICM} = 2.5\text{ V}$ ,  $V_{G-} = 0\text{ V}$ ,  $V_{G+} = 1\text{ V}$  (maximum gain),  $T_A = 25^\circ\text{C}$ , AC performance measured using the AC test circuit shown in [Figure 7-1](#) (unless otherwise noted). DC performance is measured using the DC test circuit shown in [Figure 7-2](#) (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Maximum gain	$V_{G+} = 0.9\text{ V}$		46.5		dB
Gain slope	$V_{G+} = 0\text{ V to } 0.9\text{ V}$		38.8		dB/V
Gain slope variation	$V_{G+} = 0\text{ V to } 0.9\text{ V}$		$\pm 1.5$		dB/V
Gain error	$V_{G+} = 0\text{ V to } 0.15\text{ V}$		$\pm 4$		dB
	$V_{G+} = 0.15\text{ V to } 0.9\text{ V}$		$\pm 2.25$		
Gain control input bias current			<1		$\mu\text{A}$
Gain control input resistance			40		k $\Omega$
Gain control bandwidth	Small signal -3 dB		15		MHz
<b>VOLTAGE CLAMPING</b>					
Output voltages ( $V_{OUT\pm}$ ) relative to clamp voltages ( $V_{CL\pm}$ )	Device In voltage limiting mode, $T_A = 25^\circ\text{C}$		$\pm 25$	$\pm 38$	mV
	Device In voltage limiting mode, $T_A = -40^\circ\text{C to } +85^\circ\text{C}$			$\pm 60$	
Clamp voltage ( $V_{CL\pm}$ ) input resistance	Device in voltage limiting mode		3.3		k $\Omega$
Clamp voltage ( $V_{CL\pm}$ ) limits			$V_{S-}$ to $V_{S+}$		V
<b>POWER SUPPLY</b>					
Specified operating voltage	$T_A = 25^\circ\text{C}$		5	5.5	V
	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			5.5	
Maximum quiescent current	$T_A = 25^\circ\text{C}$		40	48	mA
	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			49	
Power supply rejection ( $\pm\text{PSRR}$ )	$T_A = 25^\circ\text{C}$	70	77		dB
	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$	45			
<b>POWER DOWN</b>					
Enable voltage threshold	TTL low = shut down, $T_A = 25^\circ\text{C}$		1.4		V
	TTL low = shut down, $T_A = -40^\circ\text{C to } +85^\circ\text{C}$	1			
Disable voltage threshold	TTL high = normal operation, $T_A = 25^\circ\text{C}$		1.4		V
	TTL high = normal operation, $T_A = -40^\circ\text{C to } +85^\circ\text{C}$			1.65	
Power-down quiescent current	$T_A = 25^\circ\text{C}$		0.35	0.4	mA
	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			0.45	
Input current high	$T_A = 25^\circ\text{C}$		$\pm 9$	$\pm 16$	$\mu\text{A}$
	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			$\pm 19$	
Input current low	$T_A = 25^\circ\text{C}$		$\pm 109$	$\pm 116$	$\mu\text{A}$
	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			$\pm 119$	
Input impedance			50    1		k $\Omega$    pF
Turnon time delay	Measured to 50% quiescent current		820		ns
Turnoff time delay	Measured to 50% quiescent current		500		ns
Forward isolation in power down			80		dB
Input resistance in power down			> 1		M $\Omega$
Output resistance in power down			16		k $\Omega$

(1) Slew rate and settling time measured at amplifier output.

## 6.6 Package Thermal Data

PACKAGE	PCB	T <sub>A</sub> = 25°C POWER RATING <sup>(1)</sup>
PWP (14-pin) <sup>(2)</sup>	See <a href="#">Section 11</a> .	3 W

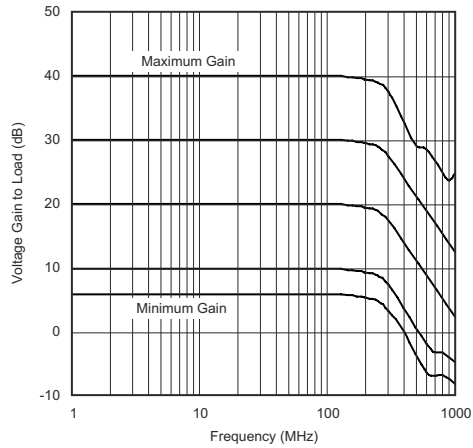
- (1) This data was taken using 2 oz trace and copper pad that is soldered directly to a 3 in × 3 in PCB.
- (2) The THS7530 incorporates a PowerPAD on the underside of the chip. The PowerPAD acts as a heatsink and must be connected to a thermally dissipative plane for proper power dissipation. Failure to do so may result in exceeding the maximum junction temperature which could permanently damage the device. See TI technical briefs [SLMA002](#) and [SLMA004](#) for more information about using the PowerPAD thermally enhanced package.

## 6.7 Typical Characteristics

Measured using the AC test circuit shown in [Figure 7-1](#) (unless otherwise noted).

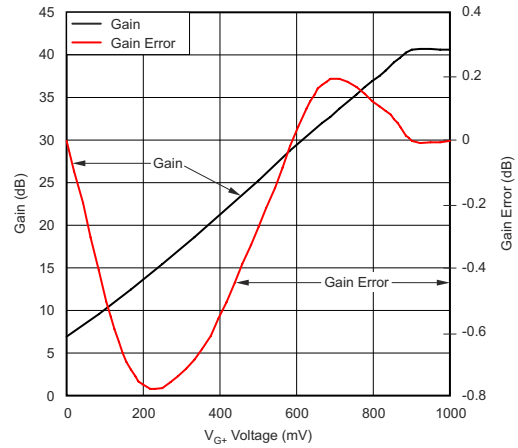
**Table 6-1. Table Of Graphs**

		FIGURE
Voltage Gain to Load	vs Frequency (Input at 45 dBm)	<a href="#">Figure 6-1</a>
Gain and Gain Error	vs V <sub>G+</sub>	<a href="#">Figure 6-2</a>
Noise Figure	vs Frequency	<a href="#">Figure 6-3</a>
Output Intercept Point	vs Frequency	<a href="#">Figure 6-4</a>
1-dB Compression Point	vs Frequency	<a href="#">Figure 6-5</a>
Total Input Voltage Noise	vs Frequency	<a href="#">Figure 6-6</a>
Intermodulation Distortion	vs Frequency	<a href="#">Figure 6-7</a>
Harmonic Distortion	vs Frequency	<a href="#">Figure 6-8</a>
S-Parameters	vs Frequency	<a href="#">Figure 9-7</a>
Differential Input Impedance of Main Amplifier	vs Frequency	<a href="#">Figure 9-8</a>
Differential Output Impedance of Main Amplifier	vs Frequency	<a href="#">Figure 6-9</a>
V <sub>G+</sub> Input Impedance	vs Frequency	<a href="#">Figure 6-10</a>
V <sub>OCM</sub> Input Impedance	vs Frequency	<a href="#">Figure 6-11</a>
Common-Mode Rejection Ratio	vs Frequency	<a href="#">Figure 6-12</a>
Step Response: 2 V <sub>PP</sub>	vs Time	<a href="#">Figure 6-13</a>
Step Response: Rising Edge	vs Time	<a href="#">Figure 6-14</a>
Step Response: Falling Edge	vs Time	<a href="#">Figure 6-15</a>

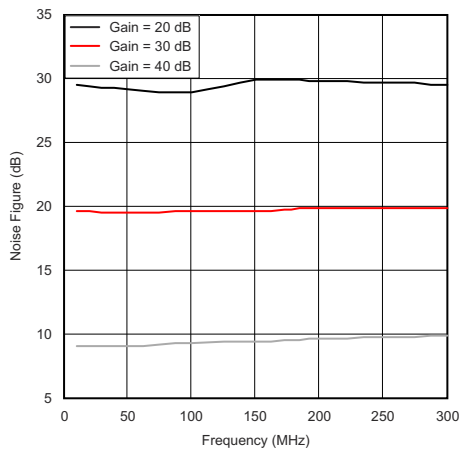


Gain is taken at load. Add 6 dB to refer to amplifier output  
 $P_{IN} = -45$  dBm

**Figure 6-1. Voltage Gain to Load vs Frequency**

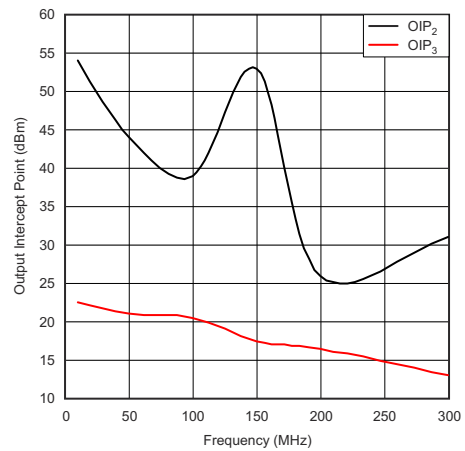


**Figure 6-2. Gain and Gain Error vs  $V_{G+}$**



Terminated input

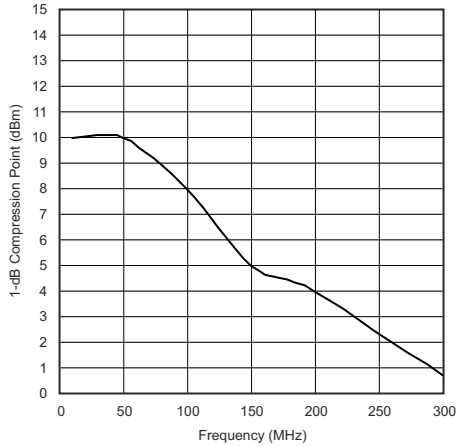
**Figure 6-3. Noise Figure vs Frequency**



Taken at load. Add 3 dB to refer to amplifier output.

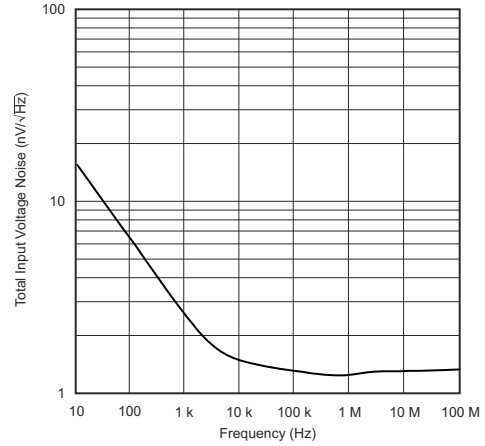
**Figure 6-4. Output Intercept Point vs Frequency**



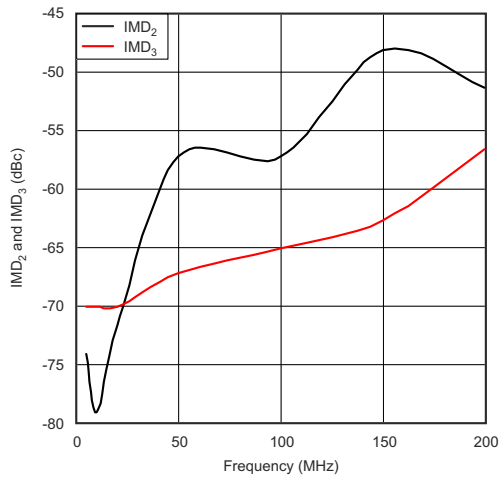


Taken at load. Add 3 dB to refer to amplifier output.

**Figure 6-5. 1-dB Compression Point vs Frequency**

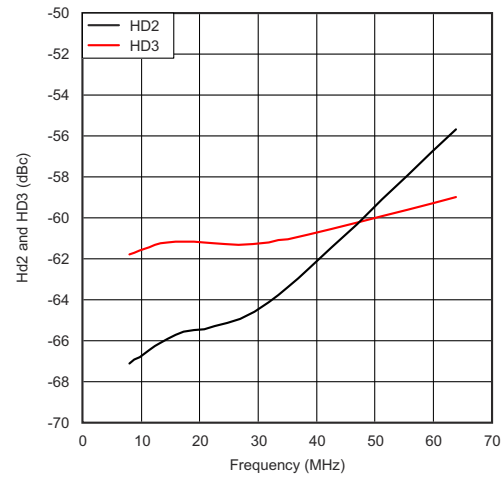


**Figure 6-6. Total Input Voltage Noise vs Frequency**



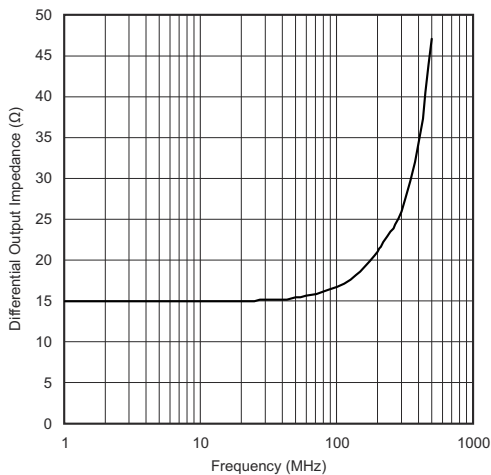
$V_{G+} = 1\text{ V}$   $V_O = 1\text{ V}_{PP}$  (composite)  $R_L = 400\ \Omega$

**Figure 6-7. Intermodulation Distortion vs Frequency**

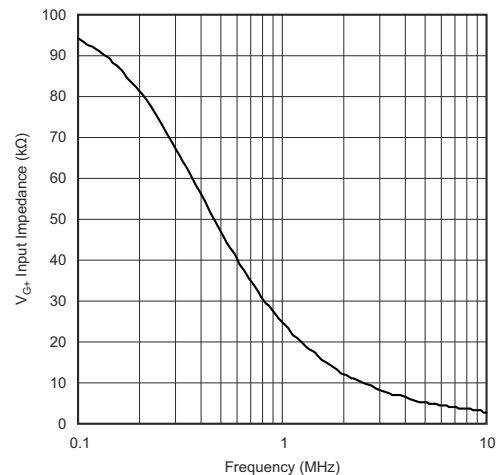


$V_{G+} = 1\text{ V}$   $V_O = 1\text{ V}_{PP}$   $R_L = 400\ \Omega$

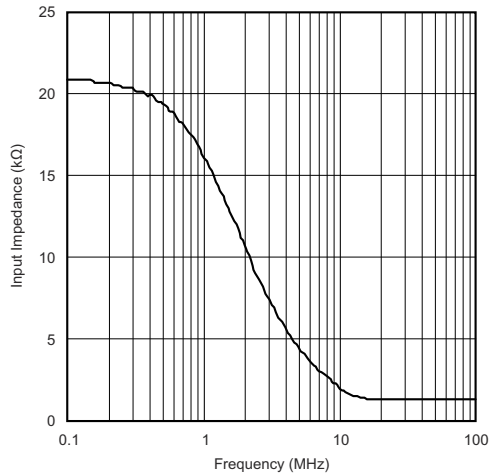
**Figure 6-8. Harmonic Distortion vs Frequency**



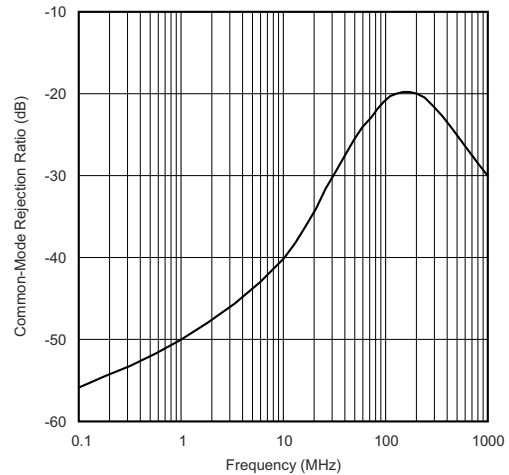
**Figure 6-9. Differential Output Impedance of Main Amplifier vs Frequency**



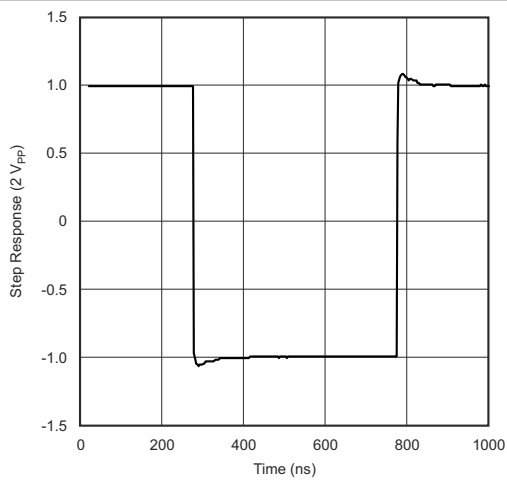
**Figure 6-10.  $V_{G+}$  Input Impedance vs Frequency**



**Figure 6-11.  $V_{OCM}$  Input Impedance vs Frequency**

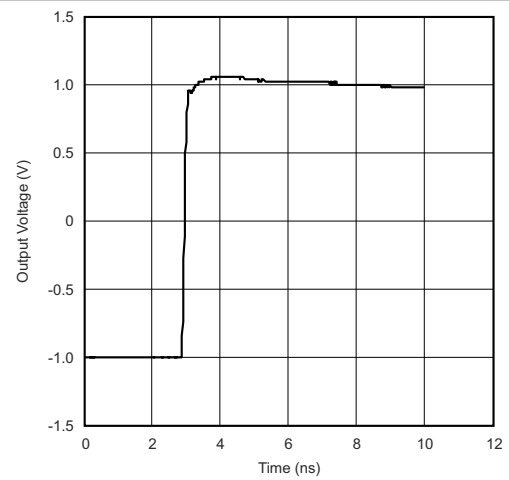


**Figure 6-12. Common-Mode Rejection Ratio vs Frequency**



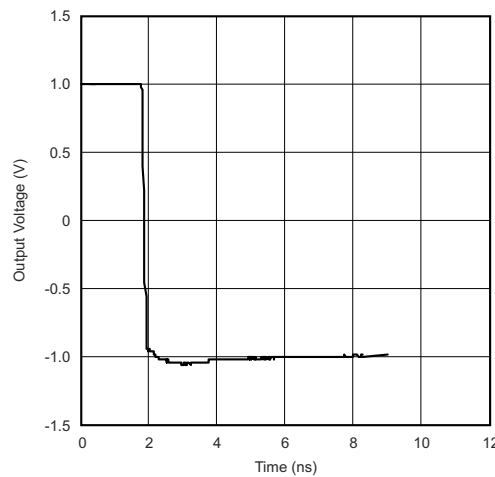
$R_L = 400 \Omega$  At amplifier output and minimum gain

**Figure 6-13. Step Response**



$R_L = 400 \Omega$  At amplifier output and minimum gain

**Figure 6-14. Step Response: Rising Edge**

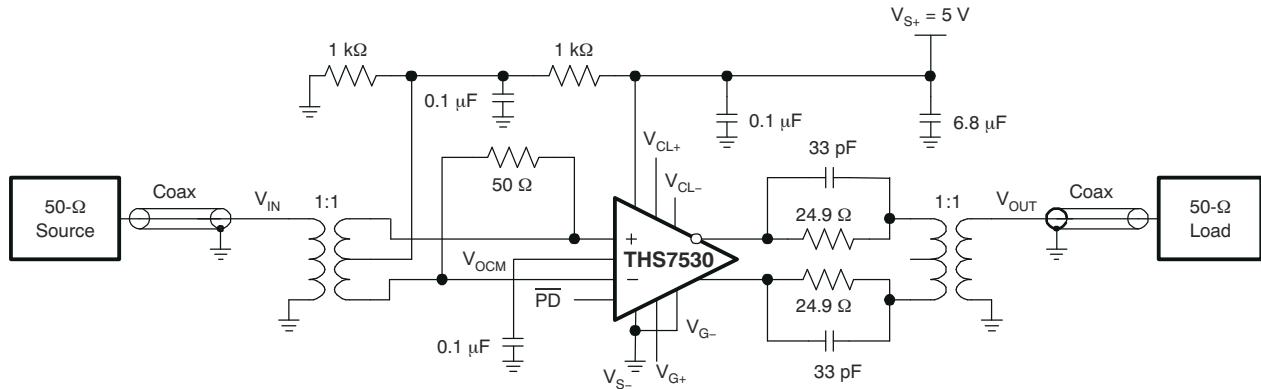


$R_L = 400 \Omega$  At amplifier output and minimum gain

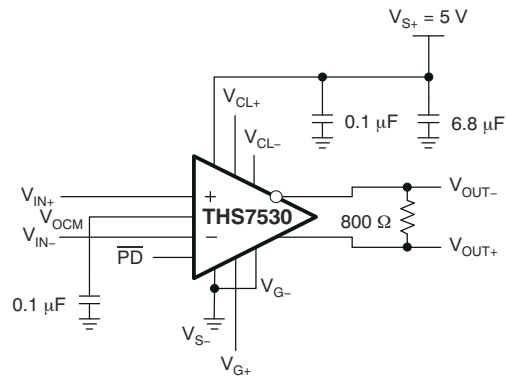
**Figure 6-15. Step Response: Falling Edge**

## 7 Parameter Measurement Information

### 7.1 Test Circuits



**Figure 7-1. AC Test Circuit**



**Figure 7-2. DC Test Circuit**

## 8 Detailed Description

### 8.1 Overview

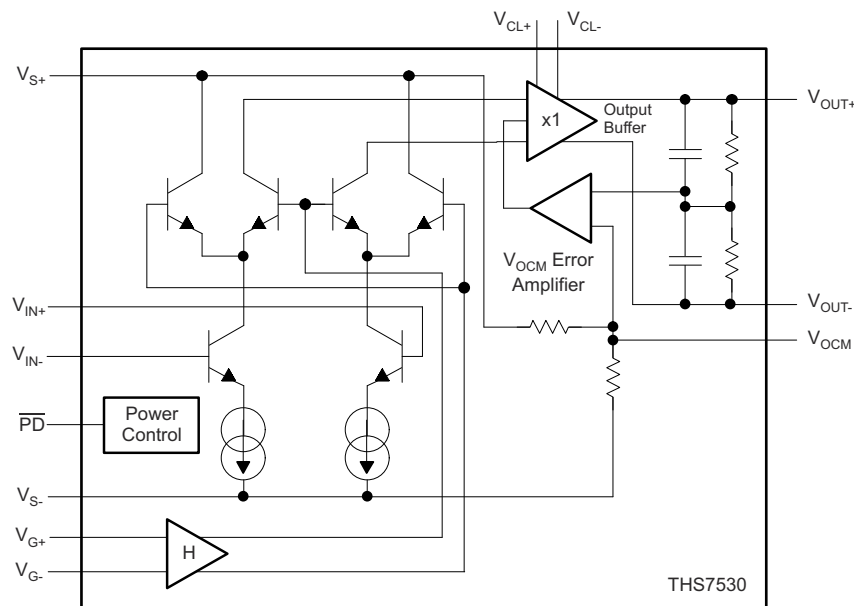
The THS7530 device is a fully-differential amplifier with 300-MHz bandwidth and with continually-variable gain from 11.6 dB to 46.5 dB. This amplifier together with an automatic gain control (AGC) circuit will precisely established a desired amplitude at its output.

The input architecture is a modified Gilbert cell. The output from the Gilbert cell is converted to a voltage and buffered to the output as a fully-differential signal. A summing node between the outputs is used to compare the output common-mode voltage to the  $V_{OCM}$  input. The  $V_{OCM}$  error amplifier then servos the output common-mode voltage to maintain it equal to the  $V_{OCM}$  input. Left unterminated,  $V_{OCM}$  is set to midsupply by internal resistors.

The gain control input is conditioned to give linear-in-dB gain control (block H). The gain control input is a differential signal from 0 V to 0.9 V which varies the gain from 11.6 dB to 46.5 dB.

$V_{CL+}$  and  $V_{CL-}$  provide inputs that limit the output voltage swing of the amplifier.

### 8.2 Functional Block Diagram



### 8.3 Feature Description

The main features of the THS7530 device are continually-variable gain control, common-mode voltage control, output voltage clamps, and power-down mode.

#### 8.3.1 Continually-Variable Gain Control

The amplifier gain in dB is a linear function of the gain control voltage, which has a range of 0 V to 0.9 V. The slope of the gain control input is 38.8 dB/V with a gain range of 11.6 dB to 46.5 dB, which is 3.8 to 211.3 V/V, respectively. The bandwidth of the gain control is 15 MHz, typically.

The gain control is a differential input to reduce noise due to ground bounce, coupling, and so forth. The negative gain-control input  $V_{G-}$  can be below the negative supply by as much as 600 mV.

#### 8.3.2 Common-Mode Voltage Control

The common-mode voltage control sets the common-mode voltage of the differential output. The gain of the control voltage is 1 V/V with a range of 1.75 V to 3.25 V above the negative supply. If unconnected, the common-mode voltage control is at mid-supply, typically 2.5 V above the negative supply. The bandwidth of the common-mode voltage control is an impressive 32 MHz.

### 8.3.3 Output Voltage Clamps

Separate inputs,  $V_{CL-}$  and  $V_{CL+}$ , establish the minimum and maximum output voltages, respectively. The typical error of the output voltage compared to the clamp voltage is only 25 mV. This feature can be used to avoid saturating the inputs of a receiving device, thereby precluding long recovery times in the signal path.

### 8.3.4 Power-Down Mode

To minimize power consumption when idle, the THS7530 device has an active-low power-down control that reduces the quiescent current from 40 mA to 350  $\mu$ A. The turnon delay is only 820 ns.

When in power-down mode, the THS7530 device has a 80-dB forward isolation to allow other devices to drive the same signal path with minimal interference from the idle THS7530 device.

## 8.4 Device Functional Modes

The THS7530 device has two functional modes: full-power mode and power-down mode. The power-down mode reduces the quiescent current of the device to 350  $\mu$ A from a typical value of 40 mA.

With a turnon time of only 820 ns and a turnoff time of 500 ns, the power-down mode can be used to greatly reduce the average power consumption of the device without sacrificing system performance.

## 9 Application and Implementation

### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 9.1 Application Information

The THS7530 device is designed to work in a wide variety of applications requiring continuously variable gain and a fully-differential signal path. The common-mode voltage control and the output voltage clamps enable the THS7530 device to drive a diverse array of receiving circuits.

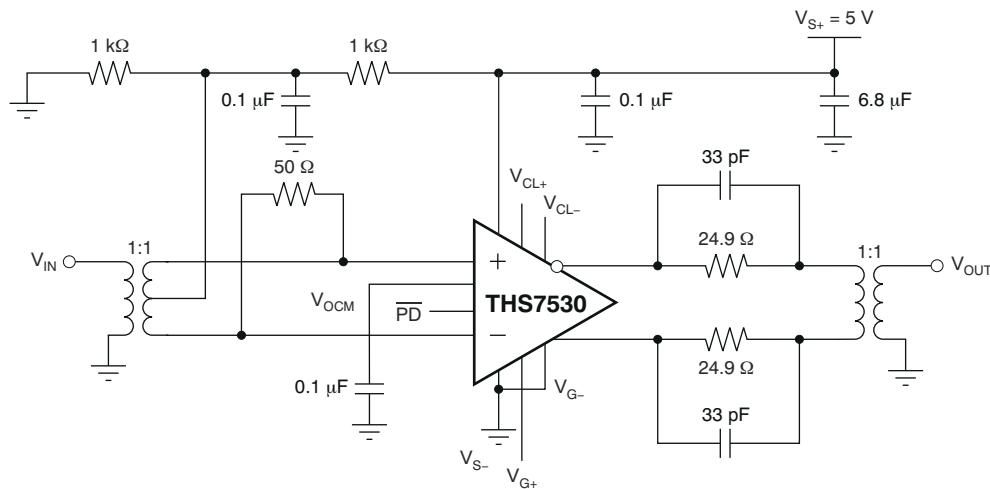


Figure 9-1. EVM Schematic: Designed for Use With Typical 50-Ω RF Test Equipment

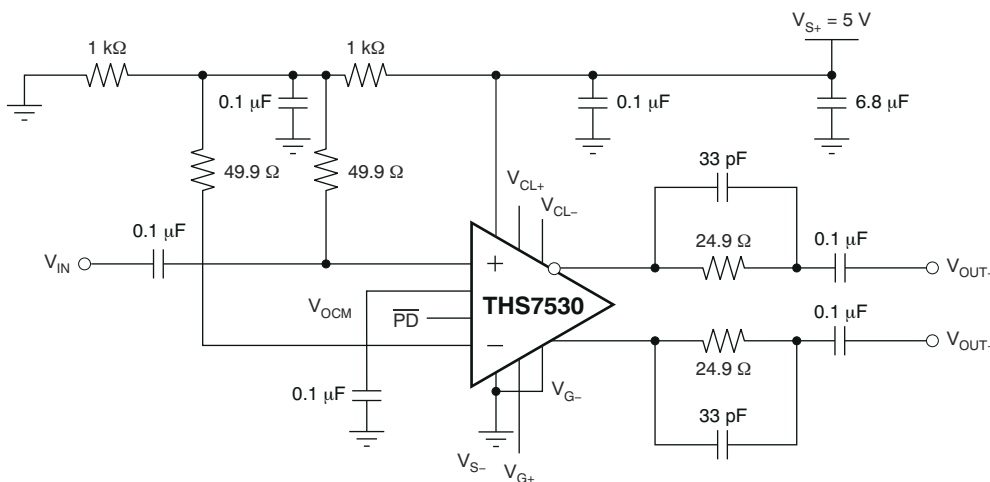
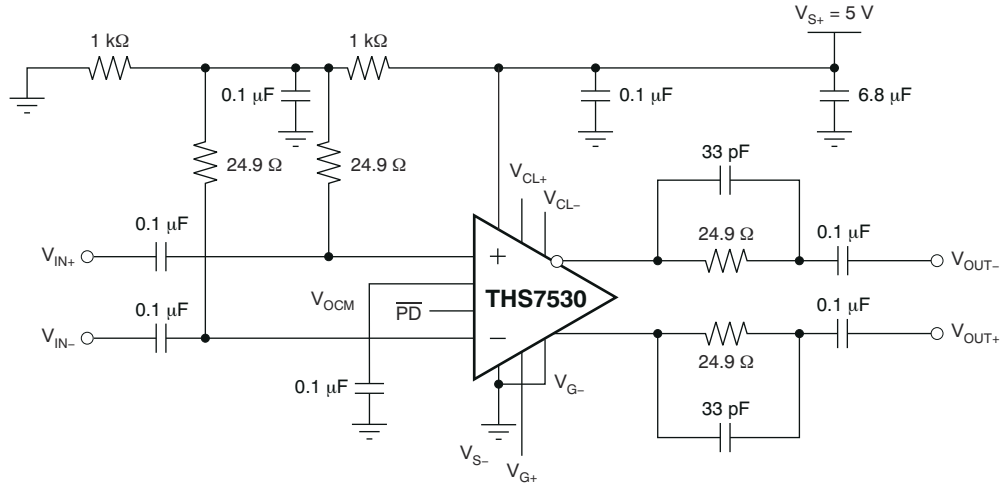
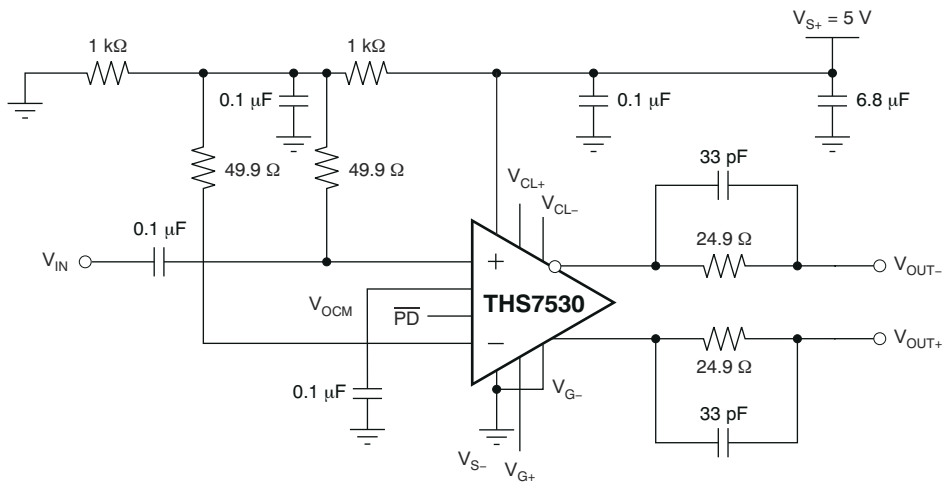


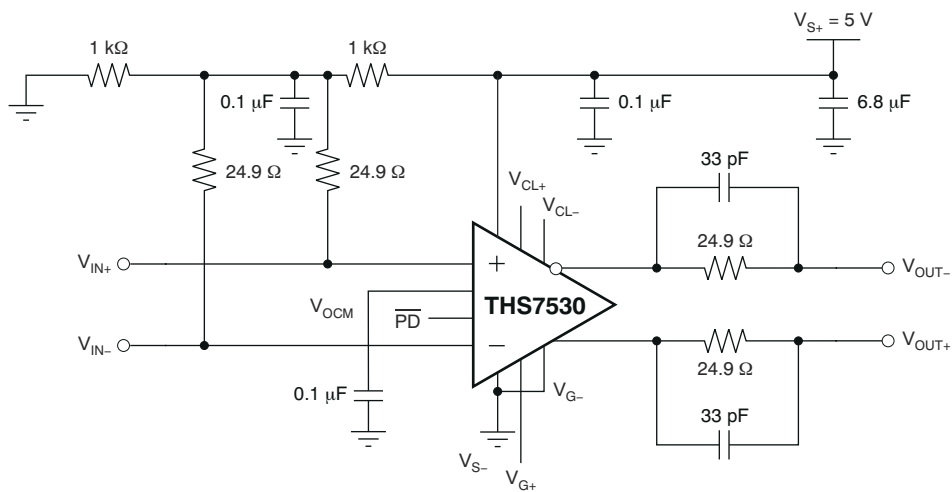
Figure 9-2. AC-Coupled Single-Ended Input With AC-Coupled Differential Output



**Figure 9-3. AC-Coupled Differential Input With AC-Coupled Differential Output**

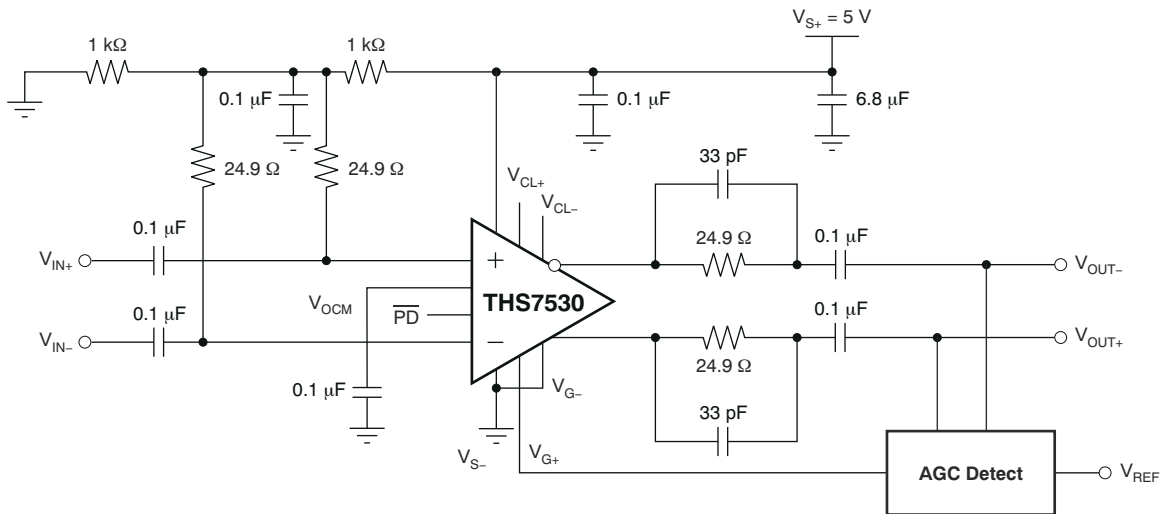


**Figure 9-4. DC-Coupled Single-Ended Input With DC-Coupled Differential Output**



**Figure 9-5. DC-Coupled Differential Input With DC-Coupled Differential Output**

## 9.2 Typical Application



**Figure 9-6. Typical Application Circuit**

### 9.2.1 Design Requirements

A typical application circuit is shown in [Figure 9-6](#). Two noteworthy aspects of this circuit are the customer's automatic gain control (AGC) circuit and the THS7530 input bias circuit.

The proper design of the AGC circuit is essential for the THS7530 device to operate properly in the customer's application. The method of detecting the amplitude of the differential output of the THS7530 device and creating the gain-control voltage,  $V_{G+}$ , from the detected amplitude and the reference amplitude,  $V_{ref}$ , are application-specific and beyond the scope of this document. The bandwidth of the amplitude of the THS7530 amplitude control is 15 MHz, which allows for rapid corrections of amplitude errors but which also allows noise from DC to 15 MHz to create an amplitude error. The trade-off between rapid amplitude correction and amplitude modulation due to noise is an important design consideration.

The input bias currents of the differential inputs of the THS7530 device are typically 20  $\mu$ A. When the differential inputs are AC-coupled, the bias currents must be supplied as shown in [Figure 9-6](#). In this circuit, the DC bias voltage is mid-supply and the AC differential input impedance is 50  $\Omega$ . The 0.1- $\mu$ F capacitor between the two 24.9- $\Omega$  resistors creates an AC ground for the driving circuit.

### 9.2.2 Detailed Design Procedure

The THS7530 device is designed for nominal 5-V power supply from  $V_{S+}$  to  $V_{S-}$ .

The amplifier has fully differential inputs,  $V_{IN+}$  and  $V_{IN-}$ , and fully differential outputs,  $V_{OUT+}$  and  $V_{OUT-}$ . The inputs are high impedance and outputs are low impedance. External resistors are recommended for impedance matching and termination purposes.

The inputs and outputs can be DC-coupled, but for best performance, the input and output common-mode voltage should be maintained at the midpoint between the two supply pins. The output common-mode voltage is controlled by the voltage applied to  $V_{OCM}$ . Left unterminated,  $V_{OCM}$  is set to midsupply by internal resistors. A 0.1- $\mu$ F bypass capacitor should be placed between  $V_{OCM}$  and ground to reduce common-mode noise. The input common-mode voltage defaults to midrail when left unconnected. For voltages other than midrail,  $V_{OCM}$  must be biased by external means.  $V_{IN+}$  and  $V_{IN-}$  both require a nominal 30- $\mu$ A bias current for proper operation. Therefore, ensure equal input impedance at each input to avoid generating an offset voltage that varies with gain.

Voltage applied from  $V_{G-}$  to  $V_{G+}$  controls the gain of the part with 38.8-dB/V gain slope. The input can be differential or single ended.  $V_{G-}$  must be maintained within  $-0.6$  V and  $0.8$  V of  $V_{S-}$  for proper operation. The negative gain input should typically be tied directly to the negative power supply.



$V_{CL+}$  and  $V_{CL-}$  are inputs that limit the output voltage swing of the amplifier. The voltages applied set an absolute limit on the voltages at the output. Input voltages at  $V_{CL+}$  and  $V_{CL-}$  clamp the output, ensuring that neither output exceeds those values.

The power-down input is a TTL compatible input, referenced to the negative supply voltage. A logic low puts the THS7530 device in power-saving mode. In power-down mode the part consumes less than 1-mA current, the output goes high impedance, and a high amount of isolation is maintained between the input and output.

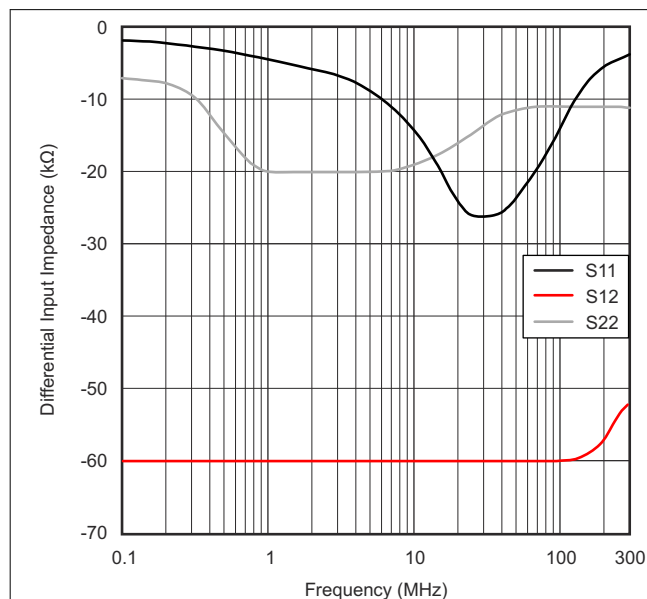
Power-supply bypass capacitors are required for proper operation. A 6.8- $\mu$ F tantalum bulk capacitor is recommended if the amplifier is located far from the power supply and may be shared among other devices. A ceramic 0.1- $\mu$ F capacitor is recommended within 0.1-in of the device power pin. The ceramic capacitors should be located on the same layer as the amplifier to eliminate the use of vias between the capacitors and the power pin.

**Table 9-1. THS7530EVM Bill of Materials**

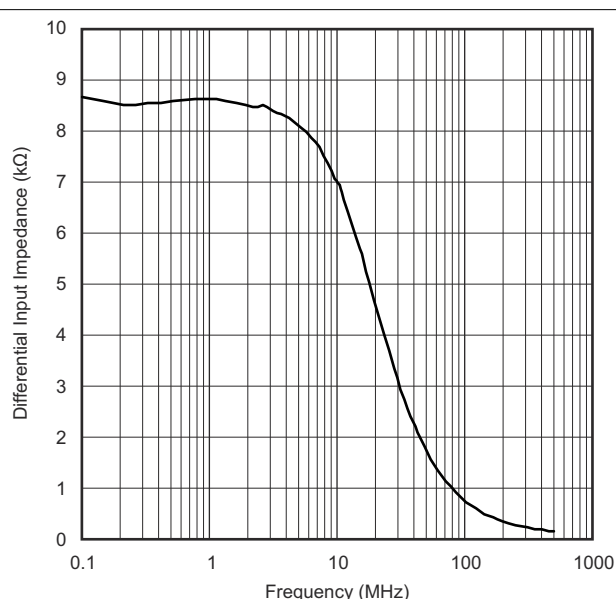
ITEM NO.	DESCRIPTION	SIZE	REFERENCE DESIGNATOR	QTY	PART NUMBER
1	Bead, ferrite, 3 A, 80 $\Omega$	1206	FB1	1	(Steward) HI1206N800R-00
2	Capacitor, tantalum, 6.8 mF, 35 V, 10%	D	C2	1	(AVX) TAJD685K035R
3	Capacitor, ceramic, 0.1 mF, X7R, 16V	508	C1	1	(AVX) 0508YC104KAT2A
5	Capacitor, ceramic, 0.1 mF, X7R, 50 V	805	C3, C7, C12, C13, C14, C15, C16, C17	8	(AVX) 08055C104KAT2A
6	Diode, Schottky, 20 V, 0.5 A	SOD-123	D1	1	(Diodes Inc.) B0520LW-7
7	Resistor, 10 $\Omega$ , 1/8 W, 1%	805	R24, R25, R26	3	(PHYCOMP) 9C08052A10R0FKHFT
8	Resistor, 24.9 $\Omega$ , 1/8 W, 1%	805	R9, R15	2	(PHYCOMP) 9C08052A24R9FKHFT
9	Resistor, 1 k $\Omega$ , 1.8W, 1%	805	R7, R12	2	(PHYCOMP) 9C08052A1001FKHFT
10	Resistor, 3.92 k $\Omega$ , 1/8 W, 1%	805	R1	1	(PHYCOMP) 9C08052A3921FKHFT
11	Resistor, 0 $\Omega$ , 1/4 W	1206	C4, C5	2	(PHYCOMP) 9C12063A0R00JLHFT
12	Resistor, 49.9 $\Omega$ , 1/4 W, 1%	1206	R4	1	(PHYCOMP) 9C12063A49R9FKRFT
13	Pot., ceramic, 1/4 inch square, 1 k $\Omega$		R2	1	(Bourns) 3362P-1-102
14	Pot., ceramic, 1/4 inch square, 10 k $\Omega$		R21, R22, R23	3	(Bourns) 3362P-1-103
15	IC, TLV2371	SOT-23	U2, U3, U4	3	(TI) TLV2371IDBVT
16	Transformer, 1:1	CD542	T1, T2	2	(Mini-Circuits) ADT1-1WT
17	Connector, edge, SMA PCB Jack		J3, J4	2	(Johnson) 142-0701-801
18	Jack, banana receptacle, 0.25-in diameter hole		J1, J2	2	(HH Smith) 101
19	Header, 0.1-in Ctrs, 0.025-in square pins	2 POS.	JP1	1	(Sullins) PZC36SAAN
20	Shunts		JP1	1	(Sullins) SSC02SYAN
21	Test point, black		TP2, TP3, TP4	3	(Keystone) 5001
22	Test points, red		TP1, TP8, TP9, TP10	4	(Keystone) 5000
23	Standoff, 4-40 Hex, 0.625-in Length			4	(Keystone) 1804
24	Screw, Phillips, 4-40, .250-in			4	SHR-0440-016-SN
25	IC, THS7530		U1	1	(TI) THS7530PWP
26	Board, printed circuit			1	(TI) EDGE # 6441987

### 9.2.3 Application Curves

Figure 9-7 and Figure 9-8 highlight the input characteristics of the THS7530 device that should be used to design the circuit driving the THS7530 device.



**Figure 9-7. S-Parameters vs Frequency**



**Figure 9-8. Differential Input Impedance of Main Amplifier vs Frequency**

## 10 Power Supply Recommendations

The THS7530 device is principally intended to operate with a nominal single-supply voltage of 5 V. Supply voltage tolerances of  $\pm 10\%$  are supported. The absolute maximum supply is 5.5 V.

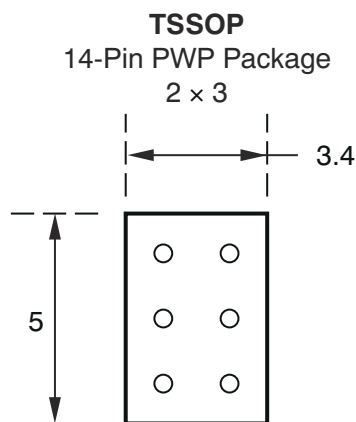
Supply decoupling is required, as described in [Section 9](#).

Split (or bipolar) supplies can be used with the THS7530 device, as long as the total value across the device remains less than 5.5 V (absolute maximum).

## 11 Layout

### 11.1 Layout Guidelines

The THS7530 device is available in a thermally-enhanced PowerPAD™ package. Figure 11-1 shows the recommended number of vias and thermal land size recommended for best performance. Thermal vias connect the thermal land to internal or external copper planes and should have a drill diameter sufficiently small so that the via hole is effectively plugged when the barrel of the via is plated with copper. This plug is needed to prevent wicking the solder away from the interface between the package body and the thermal land on the surface of the board during solder reflow. The experiments conducted jointly with Solectron Texas indicate that a via drill diameter of 0.33 mm (13 mils, or .013 in) or smaller works well when 1-ounce copper is plated at the surface of the board and simultaneously plating the barrel of the via. If the thermal vias are not plugged when the copper plating is performed, then a solder mask material should be used to cap the vias with a dimension equal to the via diameter + 0.1 mm minimum. This prevents the solder from being wicked through the thermal via and potentially creating a solder void in the region between the package bottom and the thermal land on the surface of the PCB.



**Figure 11-1. Recommended Thermal Land Size and Thermal Via Patterns (Dimensions in mm)**

See TI's Technical Brief titled, *PowerPAD™ Thermally Enhanced Package (SLMA002)* for a detailed discussion of the PowerPAD™ package, its dimensions, and recommended use.

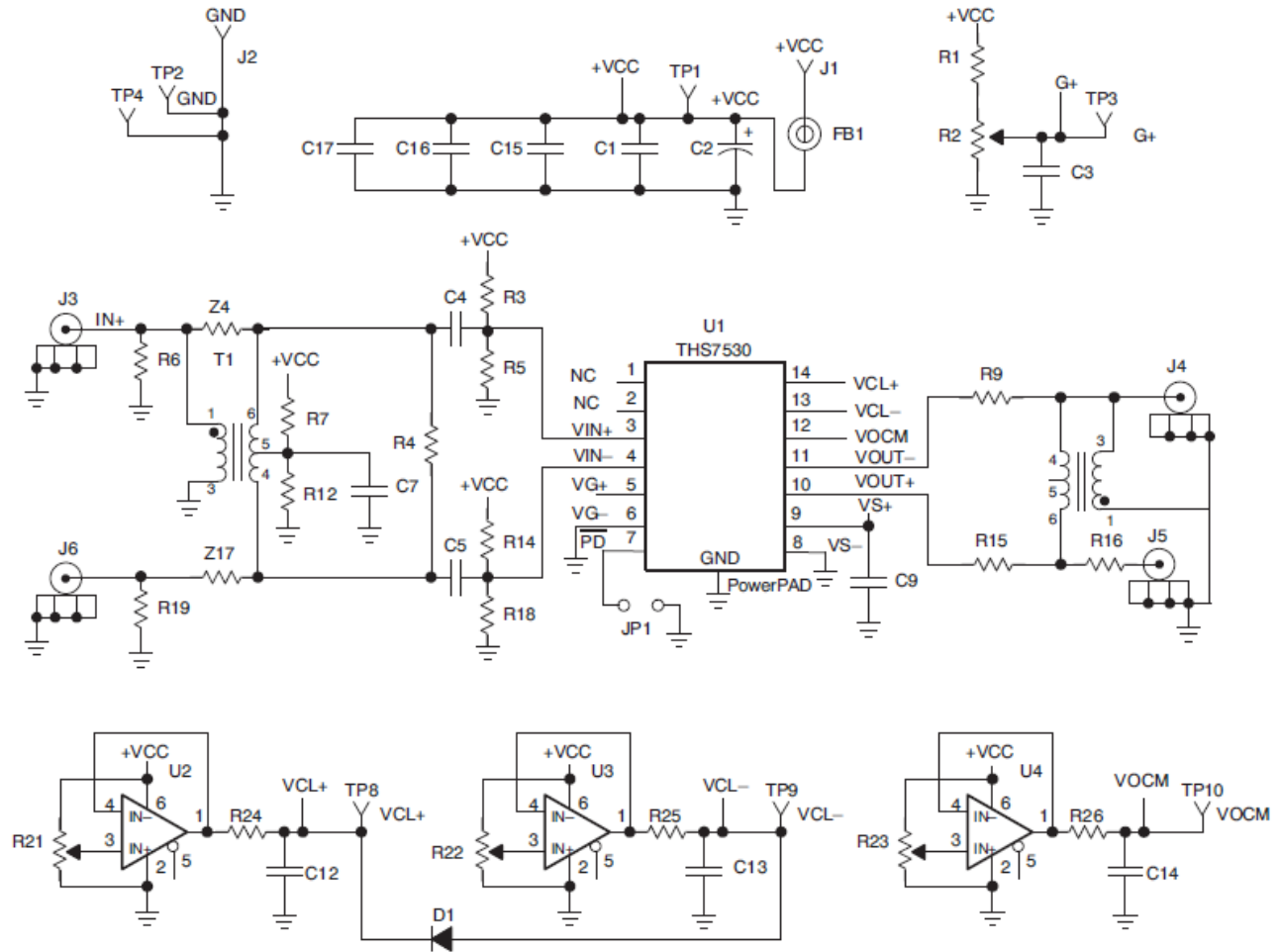


Figure 11-2. EVM Schematic

## 11.2 Layout Examples

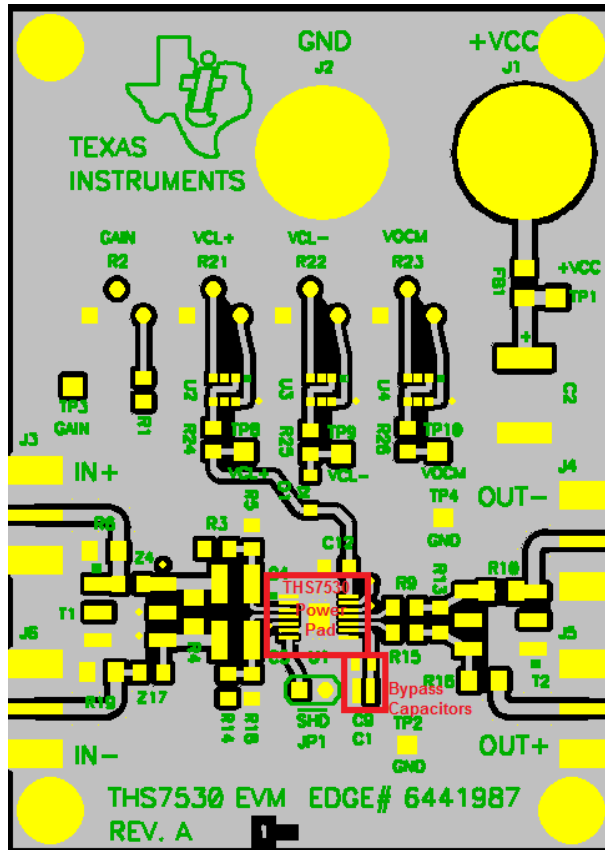


Figure 11-3. Layout Diagram (Top)

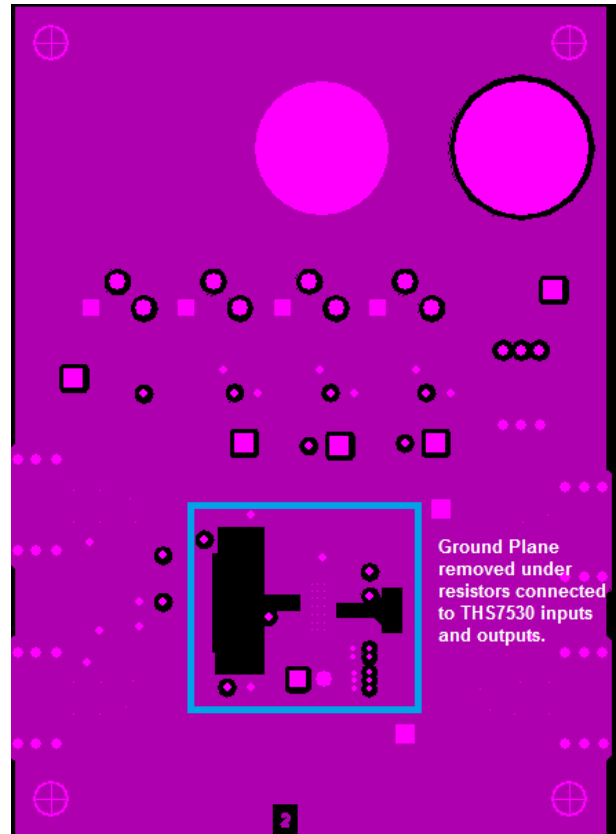


Figure 11-4. Layout Diagram (Ground)

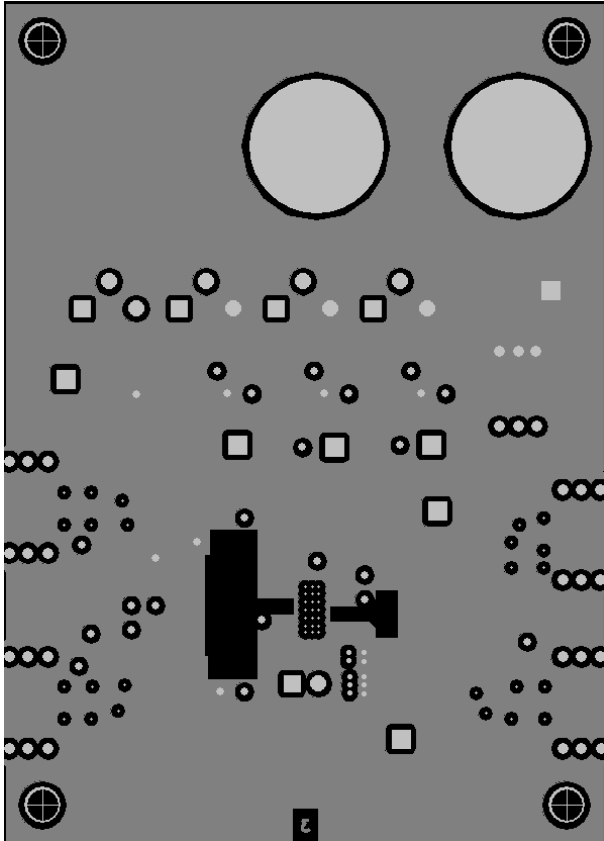


Figure 11-5. Layout Diagram (Power)

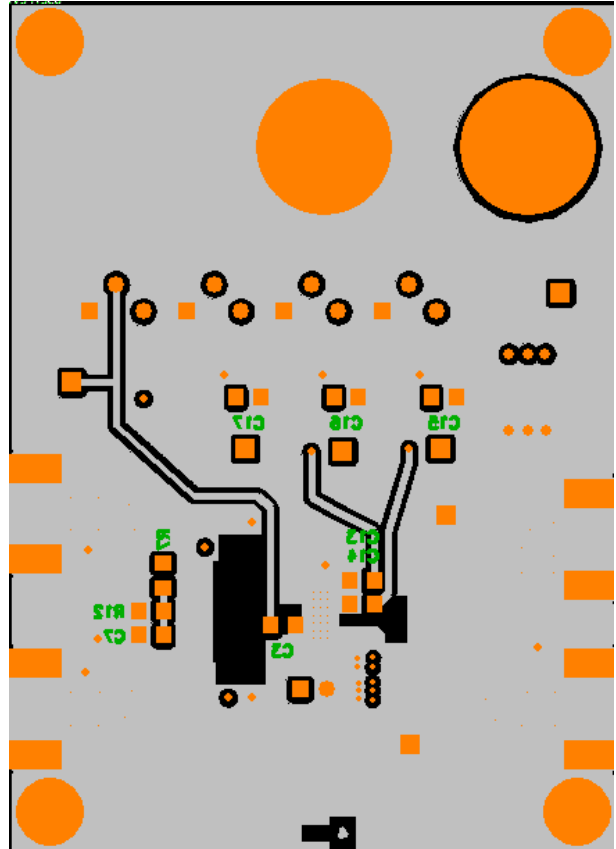


Figure 11-6. Layout Diagram (Bottom)

## 12 Device and Documentation Support

### 12.1 Device Support

#### 12.1.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

#### 12.1.2 Development Support

For the THS7530 PSpice Model, see [SLOJ139](#).

For the THS7530 TINA-TI Spice Model, see [SLAM020](#).

For the THS7530 TINA-TI Reference Design, see [SLAC091](#).

### 12.2 Documentation Support

#### 12.2.1 Related Documentation

For related documentation, see the following:

- *THS7530 EVM Users Guide*, [SLOU161](#)
- *Noise Analysis for High-Speed Op Amps*, [SBOA066](#)
- *TI's Analog Signal Chain Guide*, [SLYB174](#)
- *PowerPAD™ Thermally Enhanced Package*, [SLMA002](#)
- *PowerPAD™ Made Easy*, [SLMA004](#)

### 12.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 12.4 Trademarks

PowerPAD™ is a trademark of Texas Instruments.

TI E2E™ is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

### 12.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 12.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
THS7530PWP	ACTIVE	HTSSOP	PWP	14	90	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	THS7530	<a href="#">Samples</a>
THS7530PWPR	ACTIVE	HTSSOP	PWP	14	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	THS7530	<a href="#">Samples</a>

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.



**OTHER QUALIFIED VERSIONS OF THS7530 :**

- Automotive: [THS7530-Q1](#)

## NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
THS7530PWPR	HTSSOP	PWP	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
THS7530PWPR	HTSSOP	PWP	14	2000	350.0	350.0	43.0

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
THS7530PWP	PWP	HTSSOP	14	90	530	10.2	3600	3.5

## GENERIC PACKAGE VIEW

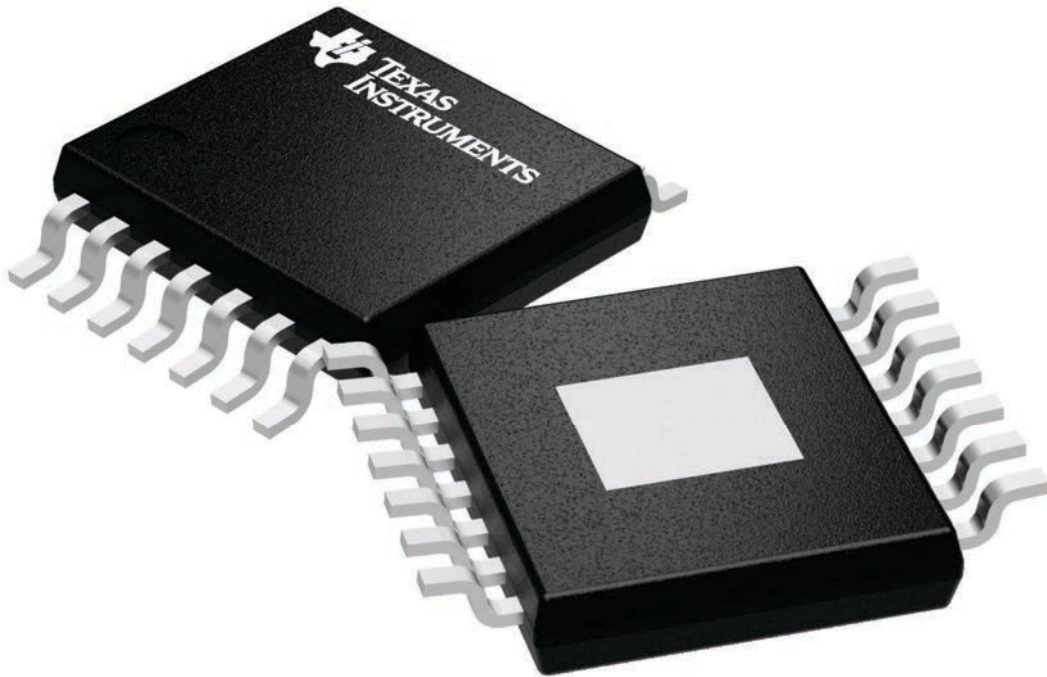
**PWP 14**

**PowerPAD TSSOP - 1.2 mm max height**

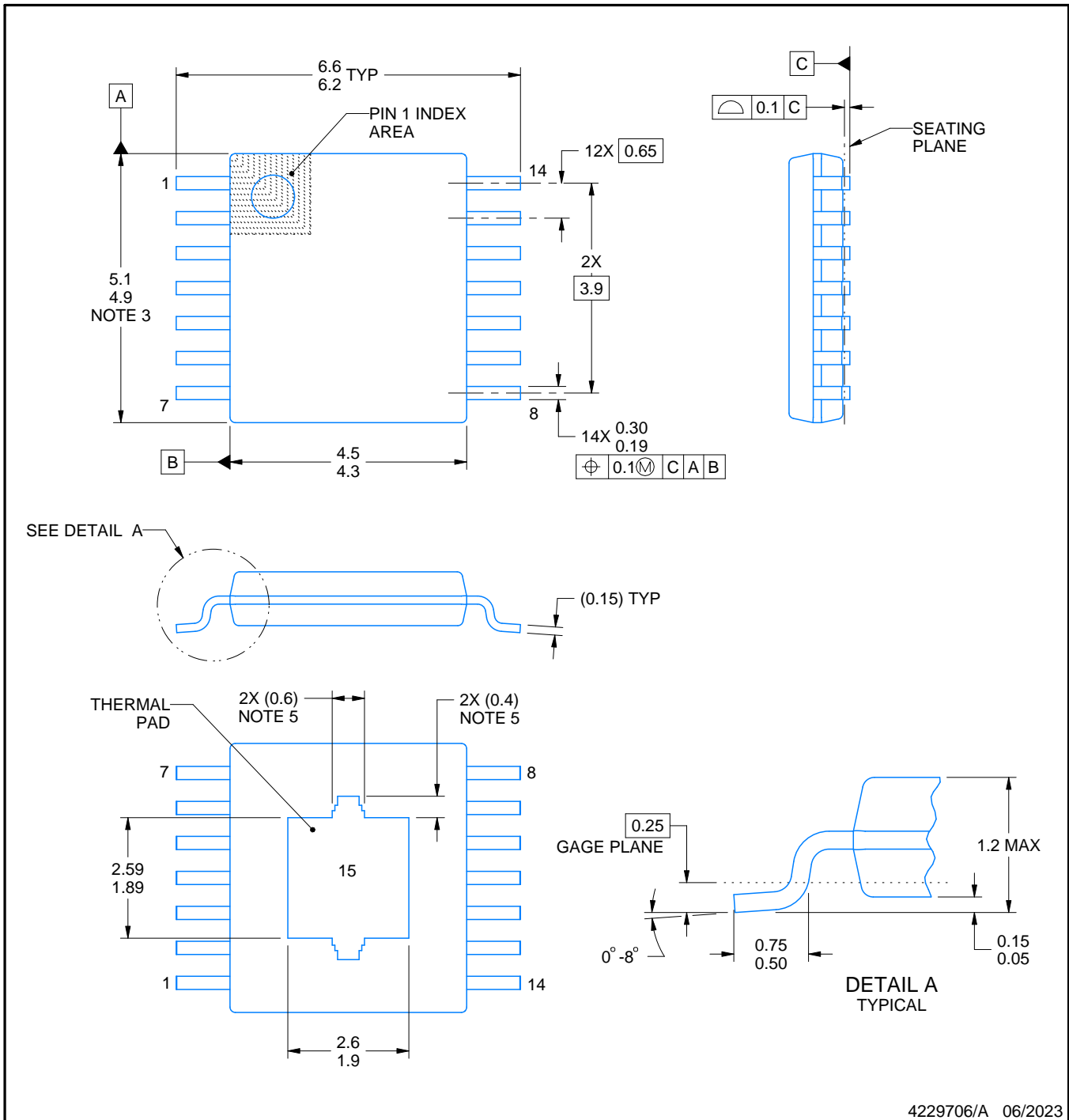
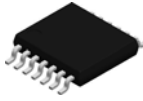
4.4 x 5.0, 0.65 mm pitch

PLASTIC SMALL OUTLINE

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4224995/A



4229706/A 06/2023

NOTES:

PowerPAD is a trademark of Texas Instruments.

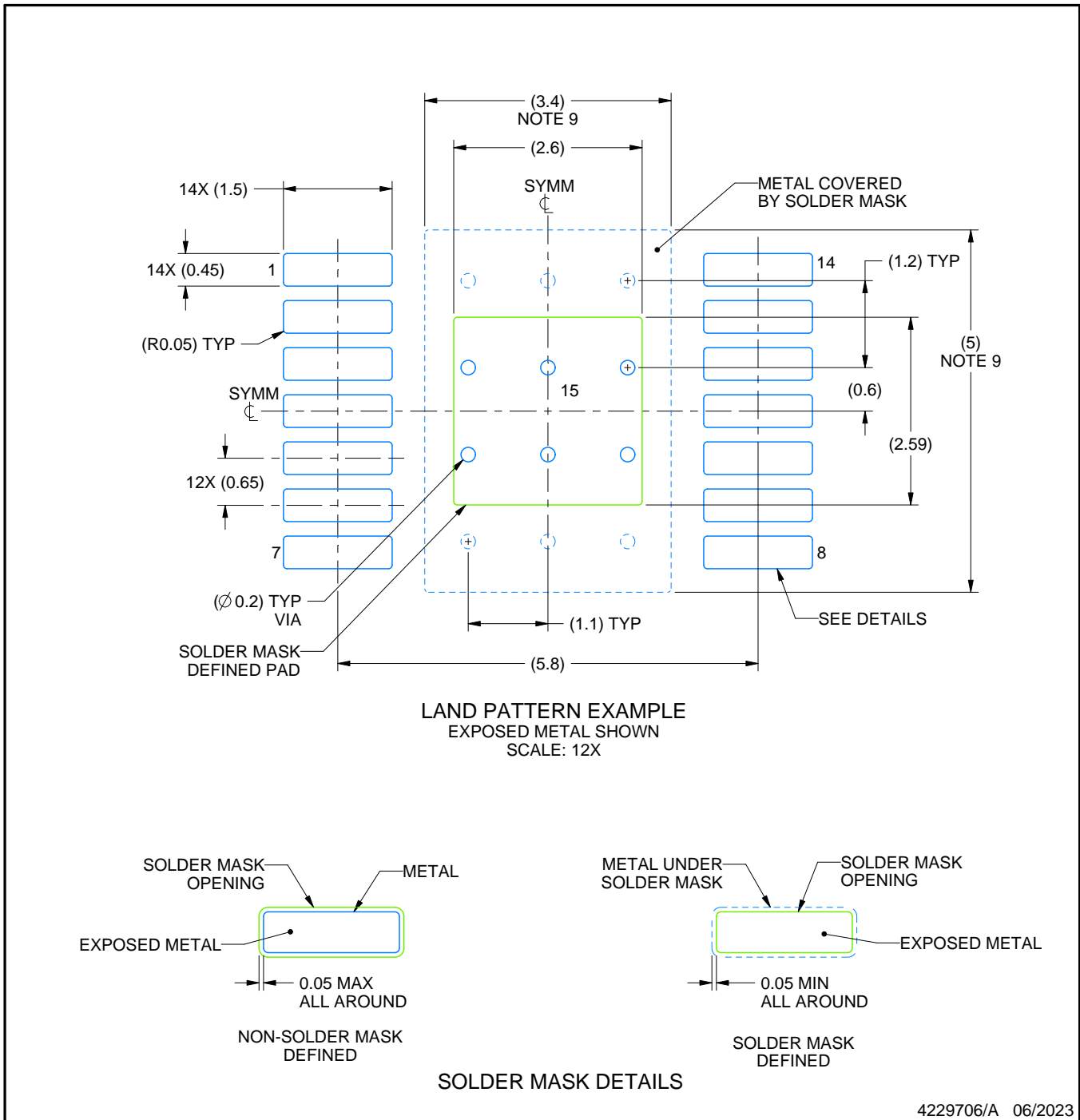
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-153.
5. Features may differ or may not be present.

# EXAMPLE BOARD LAYOUT

PWP0014K

PowerPAD™ TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



NOTES: (continued)

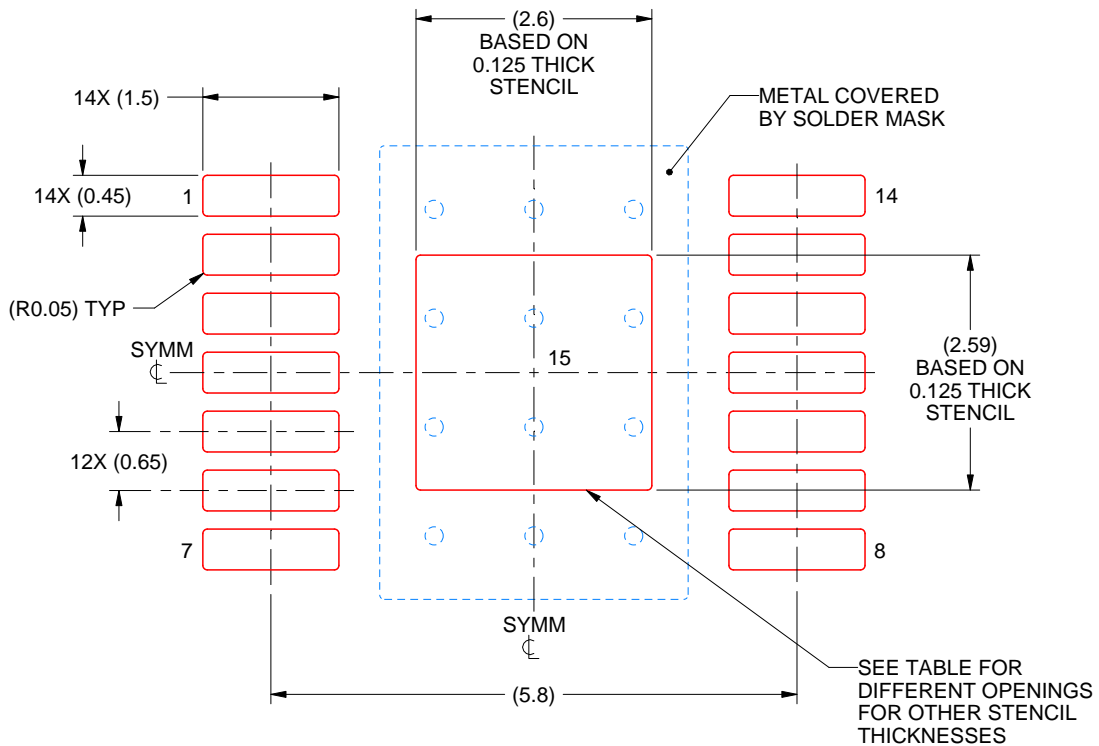
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 ([www.ti.com/lit/slma002](http://www.ti.com/lit/slma002)) and SLMA004 ([www.ti.com/lit/slma004](http://www.ti.com/lit/slma004)).
9. Size of metal pad may vary due to creepage requirement.
10. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

PWP0014K

PowerPAD™ TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 12X

STENCIL THICKNESS	SOLDER STENCIL OPENING
0.1	2.91 X 2.90
0.125	2.60 X 2.59 (SHOWN)
0.15	2.37 X 2.36
0.175	2.20 X 2.19

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NOTES: (continued)

11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.



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